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Mechanism of the Direct or Substantive Dyeing of Cellulosic Fibers*

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IF a skein or piece of viscose rayon or of cotton is placed in an aqueous solution of a substantive dye containing some salt and heated to 180° to 210° F, the solution is rapidly decolorized and the fiber is strongly colored, the color remaining after rinsing and drying. This is the fundamental direct dyeing process. The deposition of the dye upon the fiber is very rapid, indeed so rapid that it arouses astonishment when first seen, and even to those familiar with it it remains surprising and the mechanism of the process continues to arouse intense interest. Salt, dye, and fiber are all inert materials and yet this very positive rearrangement takes place by which the dye is fixed upon the cellulose fiber.

Conditions Necessary for Dyeing

As might be expected, closer observation shows that certain conditions must be fulfilled in order for dyeing to take place.

1. The dye must belong to a group of colored organic substances of peculiar constitution. Besides being highly colored it must be highly unsaturated without being unstable. This characteristic is found to perfection in the ring structures of benzene, naphthalene, anthracene, and some others. It must contain a long system of conjugated double bonds such as that found in two benzene rings united by the azo group. It must belong to a class of colored electrolytes that are very readily converted to colloidal micelles. The micellar particles that form by the association of molecules in the presence of sodium ions must not exceed or be below certain definite dimensions under the conditions of dyeing. It is remarkable that this should be so in spite of the fact that it is not the micelles but molecules that actually color the fiber. The critical dimensions have been found by Lenher and Smith [1] to lie between 1.7 and 2.0×10^{-7} cm.

2. The dye bath must contain a concentration of sodium ions which is greater than that produced by the dissociation of the very highly ionized dye itself. In other words, salt or Glauber's salt must be added.

Characteristics of the Dye Bath

1. Direct dyeing is an equilibrium process. It progresses very slowly at room temperature, very rapidly near the boiling point. At the boil there is

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less dye on the fiber than there is at a lower temperature. The actual equilibrium will depend upon the temperature, and therefore the strength of dyeing will depend upon the temperature of the dye bath when the fiber is removed.

2. Equilibrium is dependent upon the amount of electrolyte present up to the concentration that interferes with dyeing by causing flocculation.

3. Equilibrium is dependent upon the concentration of the dye.

4. It is dependent upon the constitution of the dye.

5. Equilibrium is dependent upon the kind of fiber. Cotton does not dye as viscose rayon does even though the dye bath is identical.

The fact that the rate of dyeing and the final result depend upon the nature of the fiber makes the dyeing process an admirable tool in studying fibers. It also makes the change in dyeing properties with known changes in fiber structure the best method of studying the mechanism of dyeing.

Dyeing Mercerized Cotton

The process of mercerization is the oldest method of altering the characteristics of cotton. It has been so important not only because of the added luster it imparts to the fiber but also because it renders the fiber more sensitive to subsequent chemical treatment of all kinds. In consequence, the actual alterations in the fiber structure have been most carefully studied and, since the process also alters the dyeing characteristics of the fiber, mercerized cotton is a very suitable material to study in the effort to correlate fiber structure and dyeing properties. It is a kind of rayon made without disintegrating the fiber.

When cotton is mercerized four changes result:

1. The arrangement in space of the atoms in the main valency chains is changed, giving rise to a modified x-ray diffraction pattern, one that indicates that the chains have rotated on their long axes and drawn closer to the fiber axis. This new pattern is the one shown by rayons. This change is reversible and is a simple case of polymorphism.

2. The ratio of amorphous to crystalline cellulose is altered; the fiber becomes less crystalline.

3. The outward structure of the cotton fiber is altered; the lumen almost disappears and the cross section becomes circular instead of flattened.

4. The orientation of the crystallites is altered in the direction of greater regularity, while the main valency chains are made shorter, on the average, by degradation.

Effects of Mercerizing on Dyeing

The process of mercerizing affects the dyeing of cotton in three ways:

1. The take-up of dye—that is, the rate of exhaust—is speeded up.

2. The equilibrium point is changed, more dye being taken up under like conditions.

3. The optical effect of the same quantity of dye on the fiber is altered, the dyeing being brighter and stronger on mercerized cotton.

The accelerated rate of exhaust is a matter of common experience known to anyone who is familiar with dyeing, but Boulton and Morton [2] determined the effect quantitatively. They found that in the case of two native cottons, using Sky Blue F F (dianisidine plus 2 moles of Chicago acid—Color Index No. 518), the time taken to reach half exhaustion was 1.1 and 1.4 minutes respectively. After mercerization under tension, the time required was reduced to 0.25 and 0.35 minute.

That more dye is taken up by mercerized cotton was proved by Knecht [3], who found that a sample of cotton that absorbed 1.77 percent of Benzopurpurin 4B (Tolidine plus 2 moles of naphthionic acid —Color Index No. 448) after mercerization with 20 to 30 percent caustic took up 3.60 percent.

Experiments

The author could find no record of quantitative measurements to support the dyer's belief that the same percentage of dye gives a stronger dyeing on mercerized yarn than on native cotton. To obtain figures, the following dyeings were made.*

1. Dyeing from Baths of Equal Concentration. A 10-gram skein of clean, bleached cotton was dyed in a bath containing 100 milligrams of the direct dye Pontamine Green S Conc. 125 percent (Color Index No. 583), with the usual amount of salt, and by the standard laboratory procedure.

A 10-gram skein of mercerized cotton (degree of mercerization unknown) was dyed in exactly the same manner.

When the two skeins, after drying, were com-

* For the carrying out of the necessary experimental dyeings, for judging them, and for much helpful assistance, I am indebted to Mr. L. F. Ryan of the Technical Laboratory of E. I. du Pont de Nemours & Co., to whom I wish, again, to express my thanks.

pared, the greater strength and brightness of the dyeing on mercerized yarn were quite obvious. To determine whether the extra strength was due to the take-up of more dye, the exhausted dye baths were examined in the spectrophotometer. It was found that both baths contained unexhausted dye, but that the quantities differed in the two baths. There was 13.5 percent more dye left in the bath in which the cotton had been dyed.

2. Optical Equivalents. This difference might be enough to account for the extra strength of the dyeing on the mercerized yarn. To test this assumption, dyeings were made to determine the actual amount of dye required to give equal strength as judged by the eye of an expert. This group of dyeings in which skeins of clear viscose rayon were included gave the following results. The skeins appeared to be dyed to equal strength when the cotton was dyed with 450 milligrams, the mercerized cotton with 300 milligrams, and the viscose with 250 milligrams.

In all three cases the exhausted dye baths contained some dye; the quantity was determined spectrophotometrically in each case and found to be 90, 50, and 45 milligrams, respectively. Subtracting these residual quantities from the amounts used shows that for this particular dye in this concentration 360 milligrams on cotton equal 250 milligrams on mercerized cotton equal 205 milligrams on viscose. Although the accuracy of these equivalents is limited by the difficulty of comparing dyeings of very different brightness, nevertheless the values are quantitative enough to prove that the dyer is correct in stating that mercerization, and conversion to rayon, causes a dyeing to appear stronger as well as brighter even when the dyeing is not saturated enough to make use of the capacity of the modified cellulose to adsorb more dye.

To repeat: Mercerization increases the capacity of the fiber to take up dye and it causes the dye adsorbed to produce more effect upon the observer's eye, as is also shown by the fact that in the case of dyes that will withstand treatment with strong caustic a dyeing on native cotton can be made much brighter and stronger by mercerizing.

Discussion

The very obvious question arises: How are these changes in dyeing characteristics related to the four changes in fiber organization caused by mercerizing, that have been described above?

The increased speed of dyeing is related to the increased rate of water take-up and the quicker swelling of mercerized yarn. This property is extremely important in connection with all the processes that have to do with altering cellulose chemically. It therefore has been made the subject of very much study. The conclusion has been reached that it is the alteration in the crystallite-to-gel ratio caused by the caustic treatment that is the cardinal factor in producing the greater reactivity, the easier penetrability, and the more rapid adsorption of water in mercerized cotton. But the dye molecule is enormous, rigid, and very much less mobile than that of water. How can the mere fact that water enters mercerized cotton so much more quickly cause quicker and deeper dyeing? May this not be a consequence of the characteristics of the amorphous cellulose-water complex as a solvent for the dye anions? If this very coherent gel is rendered less viscous by the association of great numbers of water molecules, then the swollen fiber may be in itself a solvent for the dye and there will then be no need to postulate open channels into which the dye can enter; rather, the condition will be that of a viscous solution in which the dye ions are free to move subject to the restrictions of the presence of so many very large molecules of cellulose. These dye ions are rigid and flat and are characterized by the hexagonal structure of the aromatic nuclei that go into their making. These large ions are much smaller than the molecules of cellulose—small enough to move among the network of crystallites. They are capable of a certain amount of internal rotation about the atomic groups connecting the nuclei. They are also armed with many polar points such as the amino, hydroxyl, and many less obvious fields of force like those around the azo groups. As a dye ion moves it becomes strongly fixed at some one point on the crystallite; then as the adsorbed but much more mobile water molecules release other points of attraction on the crystallite these are satisfied by yet other points on the dye ion. This continues until the dye is firmly attached to the crystallite. The desorption of the dye will be slower because complete release can come only when enough water molecules have happened to come into the right positions to break the attractive forces holding the whole dye ion in place.

Heat speeds the adsorption of dye because it increases the mobility of the water molecules. When equilibrium is reached, a further rise in temperature

favors the release of the dye for the same reason. While the heat also imparts a higher mobility to the dye molecules and ions and thus furthers the attainment of equilibrium, its more important effect is the dissociation of the dye micelles into molecules, for it is the ions and not the micelles of the dye that are adsorbed.

The dye ions must not be thought of as rigidly fixed. They remain where they are because the system dye-cellulose is of a lower energy level than the system water-cellulose. But even those dyes that undergo transformation to insoluble pigments after the primary adsorption on the fiber are surprisingly mobile, as is shown by the fact that azoic and vat dyes migrate on soaping and form much larger aggregates—enough to alter the shade and the light-fastness. These dyes are no longer in the form in which they were in the dye bath; they no longer have any affinity for cellulose; the fact that they move is really surprising.

Significance of the Three Other Changes. While the chief reason for the changed dyeing properties of mercerized cotton seems certainly to be the more gelatinous state of the mercerized fiber, the three other changes caused by caustic must also be considered.

The change in the position in space of the atoms in the main chains can be of little moment. It might make possible the firmer fixation of a dye molecule of a certain constitution, but that would be of secondary importance and would not touch the three major dyeing characteristics of mercerized cotton.

The difference in orientation of the crystallites may have more importance, because it is known that in the case of rayons the more highly oriented the fiber the lower the affinity for dyes. The more random orientation of mercerized cotton would favor dyeing to the extent that it made more available the surface of the crystallites. But it must be remembered in basing conclusions on the behavior of differently oriented rayons that in these fibers the total crystallinity also varies with the degree of orientation, and that it may well be that this variable is more significant than the position of the crystallites with respect to the fiber axis.

The alteration in the shape of the whole cotton fiber, the disappearance of the lumen, and the change in cross section from that of a flattened ribbon to a simple circle are not associated with any internal structural change other than the increase in cellulose gel. These changes probably have no effect on the dyeing but do have a marked effect on the transparency of the fiber, allowing light to enter and be reflected through more dyed material than is the case with native cotton, in which the light is much more scattered. This would support the dyer's opinion that he can see more color because the fiber is more translucent.

Brightness is a transparency or reflection effect, and the dye being in a condition very nearly, if not quite, monomolecular on the fiber does not cause haziness. In fact, all good dyeings are clear and not cloudy, except in the case of those dyes that are known to be pigmented, as are the azoic dyes and some of the vat dyes after soaping. The fact that this soaping process increases the light-fastness and diminishes the transparency seems to indicate that the dye, as deposited, is essentially in a monomolecular form, and that the greater the fiber transparency the greater the length of passage of light through the absorbing colored fiber. This effect may be masked by the fact that soaping also removes adherent dye pigment, as contrasted with dye actually adsorbed.

Cellulose Gel as a Dye Solvent

This interpretation of the direct dyeing process requires that we think of amorphous cellulose as a highly viscous liquid in which dye ions can dissolve under the conditions of the lower viscosity resulting from water adsorption, particularly at temperatures near the boil.

The role of the added electrolytes is an essential one. The most reasonable assumption seems to be that the negatively charged fiber repels the negative dye anion so effectively that the latter cannot come into contact with the former. The addition of highly ionized sodium salts results in a high concentration of very mobile sodium ions. These will be adsorbed on the negative fiber surfaces, and the result will be a momentary excess positive charge. This in turn will attract the negative ions of the dye as well as those from the added salt.

The dye ions will be captured by the hydrogen bonds and other surface forces and will be slowed down so much that they will be removed essentially from the solution in the neighborhood of the fibers by precipitation on the crystallite, so that others can move in. It is to be noted that this picture of the dyeing process depends upon the facts determined by

the study of the behavior of mercerized as compared with native cotton.

In the case of mercerized cotton the quick water take-up, accompanied by swelling, makes available more crystallite surface, because the water penetrates between the crystallites. These crystallite surfaces are the ones on which the dye molecules are most firmly held, and the more available they are the more rapid and the deeper the dyeing.

The Interpretation Applied to Viscose and Acetate Rayon

To explain the dyeing of viscose rayon requires no new assumptions. This fiber is more easily penetrated by water than is mercerized cotton, and in consequence it dyes even more rapidly and can adsorb more dye at saturation.

But a study of the viscose rayons furnishes data regarding the relation of the degree of orientation of crystallites to dyeing. Orientation can be controlled, within limits, by the methods used in drawing the fiber. Since a high degree of orientation is associated with a high tenacity, and since the importance of high-tenacity yarns has increased greatly, the experimenter has a well-defined group of fibers which can be arranged in order of increasing orientation. If the fibers are judged on the basis of ease of dyeing, the order would be reversed. It is quite evident that fibers of greater orientation dye more slowly and do not take up so much dye. But whether this is due to the inaccessibility of the crystallites in more orderly arrangement or to the presence of less amorphous cellulose cannot at present be determined. Probably both are involved, the lower amorphous content having the greater influence.

Acetate rayon is extremely interesting to the student of dyeing theories. Chemically the fiber differs from viscose rayon because almost two-thirds of the hydroxyl groups of the pyranose rings are acetylated. The degree of orientation is less than that of the average viscose rayon and the crystallinity is less. These facts should make the fiber easier to dye, but it cannot be dyed at all by the use of ordinary direct or acid dyes. On the other hand, dyes that dissolve in such organic substances as ethyl acetate dye it very readily, by what is a peculiar process. The dye, insoluble in water, is readily removed from fine suspension by the fiber, as if it were extracted by ether. Can this behavior be brought into any kind of relation to the dyeing of viscose? To the author this seems possible if the simple assumption is made that in acetate rayon the hydrophobic nature of the fiber makes impossible the formation of the cellulose-water gel necessary for direct dyeing. On the other hand, the fiber is composed largely of an analogous amorphous material. To dye it it is necessary to find materials that are soluble in this gel, and these will for the most part be water-insoluble. The fiber is dyed because it is a solvent, and since the dyes are water-insoluble their adsorption on the crystallites, which is necessary in the case of dyeing cotton with direct dyes, is not in effect needed or possible.

A fact that seems an exception but is not necessarily one is this: If an attempt is made to dye acetate rayon with Alizarin Saphirol (Color Index No. 1054) from an aqueous bath the yarn is merely tinted. If the dye bath contains 26 percent formic acid, a very good, clear blue dyeing results. The explanation usually given is that the acid is a swelling agent for acetate rayon and that in some way it opens up the fiber. But why should there be a preferential take-up of the dye by the fiber? There seems to be no valid reason. However, if the assumption is made that the acid is strongly adsorbed by the fiber (as it is) and that the fiber-acid mixture becomes a solvent for the dye, then the process differs in no essential way from other methods of dyeing acetate. When the acid-fiber-dye mixture is plunged into a large quantity of water, as in rinsing, the dye is left behind and the more soluble acid is flushed out.

Nylon Dyeing

Nylon is not a rayon, but its behavior in the dye bath is most interesting. It is not dyed by direct dyes in a neutral bath; it is dyed by some acid dyes and not by others. Those acid dyes that are usable dye much more rapidly if acid is present and at temperatures near the boil. The amount of dye that is taken up is strictly limited and specific for each dye. If two dyes are present one will go on first from an acid bath and then the other, if there is "room" left for it. In other words, the combining capacity is restricted and definite, as though it depended upon a chemical valence union.

R. H. Peters [4] recently reported some interesting quantitative studies on the dyeing of nylon with acid dyes. He concluded that in neutral or feebly acid baths the free amino groups of the molecule react with the acid anions to form salts. These are very weak dyeings because of the scarcity of amino

groups. When the acidity reaches a pH of 3 or below then strong dyeings result because the amido (*sic*) groups take up color and a very full shade can be obtained.

Peters would have made his statements more convincing had he told us how much penetration there was in the case of these heavy dyeings. There are acid dyes that give a surface dyeing first, but afterwards pass into the fiber because of their solubility in it. This does not mean that an isoelectric point has been reached with increasing acidity, but that the dye, primarily adsorbed on the surface, because of its solubility in nylon, migrates into the interior.

It is not easy to account for the fact that some direct- and neutral-dyeing dyes dye on nylon from a slightly acid bath. The dyeings are reasonably fast to washing and seem to be more than mere surface pigmentation, although cross sections show no more than an outer ring of color. If it could be shown that the surface of nylon adsorbs water as does cellulose, though not so strongly, there would be the possibility of conditions resembling those of direct dyeing as far as the outer layers of molecules are concerned, and the very high intensity of light absorption characteristic of direct dyes would make the dyeings relatively strong, as compared with those of acid dyes.

In general the difficulty in direct and acid dyeing of nylon is due to the hydrophobic nature of the fiber, not to a lack of bonding forces.

There are synthetic fibers like "Saran" that are so hydrophobic that they are essentially undyeable.

Resemblance of Wool and Silk and Cellulose Dyeings

To complete the study, we may turn to wool and silk. Both of these fibers dye readily from an acid bath, and there is much evidence that the attachment of the dye is partly a consequence of chemical affinity. But, in the case of indigo at least, the x-ray patterns disclose the presence of indigo crystals and these are certainly not chemically combined. There are acid colors that are also present in strong dyeings as distinct crystals and are not combined in any stoichiometric ratio. Moreover, it is well known that a weak indigo dyeing can be made using a dispersion of unreduced indigo. All of this seems to the author to go to show that wool is also dyed by solid solution and that the necessary acid acts to change the surface potential and bring the dye molecules into contact with the wool keratin.

Summary

Acetate cellulose is dyed by direct solid solution.

Cotton, viscose, and other cellulose fibers are dyed by the adsorption of specially suitable colored molecules on the crystallites but, in addition, there is dyeing by solution of the dye in monomolecular form in the cellulose gel of the fiber.

The approach of the dye to the fiber surface is promoted by the presence of sodium ions, which overcome the electrostatic resistance of the negative fiber surface.

Direct dyes that dye levelly are presumably more soluble in the cellulose gel than are those that dye unlevelly.

Wool and silk are dyed by solid solution and chemical valency forces; acid promotes the take-up of these dyes by altering the surface charge on the fiber.

The condition of dyes on all fibers is either one of solid solution or no more than a monomolecular layer on the adsorbing surface "within" or on the fiber. However, in certain cases the dye may agglomerate to form larger micelles or even to cause pigmentation.

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Study of the Tongue-Tear Test

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TEXTILE materials fail in service for a number of reasons, depending largely upon the type of use to which they are put. Although most materials fail in complex fashion involving many types of stresses and/or strains, aggravated at times by chemical degradation, some products can be said to fail primarily as the result of one kind of action. For example, the failure of parachute shroud lines is due largely to tensile forces, that of sewing threads is due to shear forces coupled with abrasion; that of laundry pads and sheets is due to heat degradation; and the failure of balloon fabrics is due to bursting forces.

In the case of apparel, the mechanics of failure are not so well defined. Garments can be said to fail or to become unserviceable because of excessive wear, serious fading, bursting of the seams, or tears caused by contact with sharp objects. In the last instance, the garment in question may catch on splinters, nails, thorny plants, or—of particular interest to the armed forces—barbed wire. It is important, therefore, to determine how a fabric fails in tear and what measures can be taken to make garments more tear-resistant.

Tear-Testing Methods

There have been a number of methods suggested for tear-testing textile fabrics, among which is the trapezoid method [1]. A test specimen is cut 3 inches wide and 6 inches long, and an isosceles trapezoid having an altitude of 3 inches and bases of 1 inch and 4 inches in length is laid off centrally on the specimen. A slit ¼ to ⅜ inch in length is made in the center of the 1-inch edge and perpendicular to it. The specimens are tested in a conventional pendulum-type testing machine with the pawls disengaged from the rack. Clamps 1-by-3 inches or more are used, with the longer dimension perpendicular to the axis of the pull. The specimens are clamped in the machine along the non-parallel sides of the trapezoid so that the cut is midway between the clamps, the short edge being tight and the longer edge lying in folds. The sample is torn across the narrow width and the average load is recorded. This procedure has been further simplified by Bellinson [2], who describes an auxiliary set of clamps for inserting the test specimens.

The Elmendorf [3] method is another procedure. Specimens 2.5 inches wide and 4 inches long are placed in the jaws of a special tester, one jaw of which is stationary and the other is carried on a pendulum which is formed by a sector of a wheel. By the use of a swinging knife blade, a slit is cut in the sample, starting at the bottom edge and ending about 1¾ inches from the top edge. In testing, the sector is allowed to fall, thus moving the pendulum jaw away from the fixed jaw and thereby tearing the specimen. The difference in height between the maximum free swing of the pendulum and the maximum height with the sample in place is indicative of the tear-resistance of the fabric.

Recently there has been described a method for testing a fabric's resistance to tear, called the Finch Tear-Resistance Test [4]. Samples 1 inch wide by 8 inches long are passed through an opening in a special stirrup described in Chemical Warfare Service drawing No. E18-56-1. This stirrup is mounted in the top jaw of a conventional tensile tester. Its essential parts consist of a forked piece to which is clamped a rectangular plate which has piano wire 0.025 inch in diameter soldered on the top edge at an angle of 15 degrees with the horizontal. The free ends of the test specimen are clamped in the pulling jaw of the machine and the load required to tear the fabric is noted.

Still another method used for evaluating the resistance of a fabric to tear is the tongue-tear test [1]. Specimens 3 inches by 8 inches are prepared, the longer dimension being perpendicular to the system of yarns under test. A longitudinal cut 3 inches in length is made, starting in the middle of one of the shorter edges. The two tongues thus provided are

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clamped one in each jaw of a standard tensile testing machine, preferably with front and rear jaws at least 1½ inches wide. With the pawls disengaged from the rack, the machine is started and the average force required to tear the fabric is noted. It should perhaps be pointed out that if the specimen under test is much stronger in one direction than in the other, the tongue-tear test will fail in the weaker direction regardless of how the specimen is cut.

Purpose of Study

The present study was undertaken in order to determine the mechanism of failure in the tongue-tear test. It is a relatively simple procedure to prepare tongue-tear specimens and test them in the specified manner, but only by a complete understanding of what takes place in the specimen during rupture can one intelligently apply any changes in fabric structure that would result in improved tear-resistance. It has often been assumed that tongue-tear tests introduce shear effects or transverse loadings in the system of yarns perpendicular to the direction of test. If this were the case, these transverse forces would introduce compressional forces on the yarns under test and also produce bending effects. In addition, there is the possibility that the yarns under test may be failing in tension. The experimental procedure followed was designed to distinguish between these hypotheses.

Procedure

The first step consisted of the photographing of various samples which were undergoing a tongue-tear test. Tongue-tear test samples were set up between the jaws on a twist tester. A weight of 200 grams was hung from one jaw, imposing a load of 200 grams on the sample. The sample was then photographed in plan, yielding Figure 1. On the same sample the load was increased to 1,000 grams (Figure 2) and 2,000 grams (Figure 3). When the load was increased to 3,000 grams the sample broke and a photograph (Figure 4) was then made with a load sufficient to straighten the sample.

These photographs led to an hypothesis on the mechanism of failure in a tongue-tear test, as follows: On application of force to the fabric by the testing machine, the yarns held longitudinally between the jaws stretch and lose crimp and then start slipping across the transverse yarns, forming a del*-shaped (∇) opening, in which there are no longitudinal yarns. As the load is increased the longitudinal yarns continue to slip and crowd together, increasing the size of the ∇ and

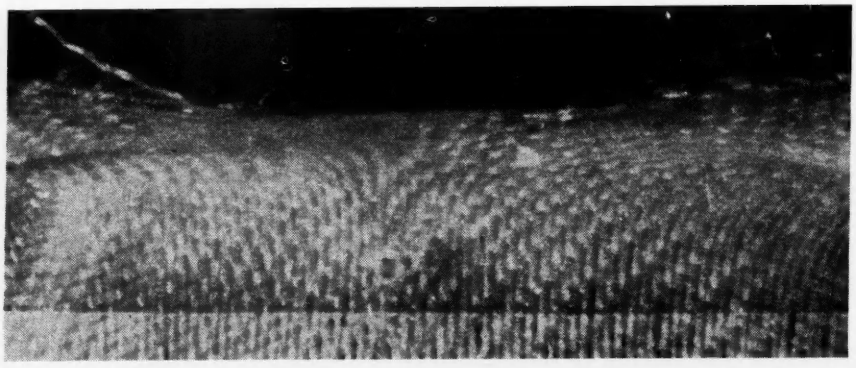

FIG. 1. *Photograph of del-shaped opening under 200-gram load.*

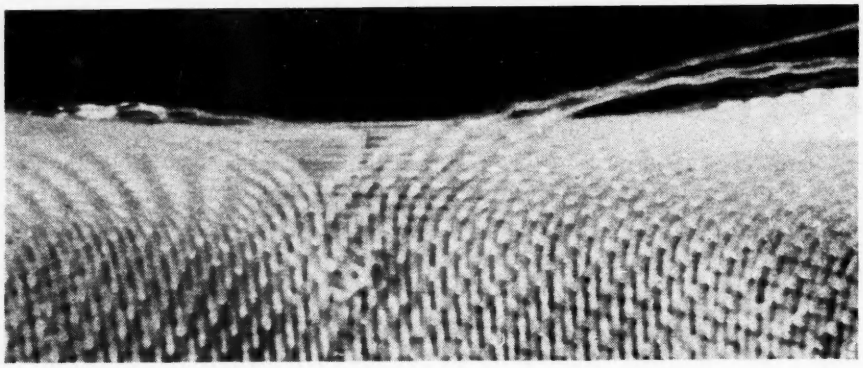

FIG. 2. *Photograph of del-shaped opening under 1,000-gram load.*

* Del—an operator used in vector analysis operating as:

$$\left(\frac{i\partial}{\partial x}+\frac{j\partial}{\partial y}+\frac{k\partial}{\partial z}\right).$$

forming a large number of frictional points of contact in a small area of fabric. As the number of these contact points builds up it becomes more and more difficult for slippage to occur, and the load is progressively transferred to the transverse yarns, which are held in tension in the ∇-shaped "pseudo jaw." As the load builds up further, some of the transverse yarns fail once more and again yarns slip by each other to form a new "pseudo jaw"; and so on, in a cycle, until the failure extends over the length tested. Thus, according to this hypothesis, failure of the yarns in a tongue-tear test occurs in tension, while the yarns are at an angle to the line of action of the jaws.

The hypothesis immediately explains the occurrence of the maxima and minima on the tongue-tear diagram. As load is applied to the specimen, the jaws of the machine separate, as longitudinal yarns first slip by each other, and then apply load to the transverse yarns. When some of the transverse yarns fail, the pendulum falls back, thus showing a drop in load. The slipping of the longitudinal yarns takes place during this drop in load, and the minimum point occurs when the friction forces within the fabric exert a load on the upper jaw which is large enough to overcome the effective weight of the pendulum. Then the load increases once more up to a maximum, at which point the next failure occurs. And so the cycle continues.

In order to check the hypothesis experimentally, fabrics * were obtained which were alike in every particular except that the number of picks per inch varied as follows: 50, 70, 100, 120, 130, 140, 150, 160. Samples selected at random from these fabrics were submitted to tongue-tear tests. Tests were run randomly in time—that is, samples with given characteristics were not all tested consecutively but at random times, to obviate any bias of environment with time. The resulting diagrams were analyzed to determine the frequency of maxima, and these data are reported, for convenience, in cycles per 3-inch length of chart. Because the chart was run at the same speed in all tests, these units allow a good comparative measure.

For purposes of analyzing tear-test diagrams, the term "wave" is used to mean that portion of the load-elongation curve which lies between two successive maxima. A maximum point is defined as any point immediately preceding a line that shows a large decrease in load. Correlation analyses were run between frequency of maxima and fillingwise fabric count and from these same tests the tearing

* Appreciation is expressed to the Laboratory Division of the Warwick Mills, which kindly provided these fabrics.

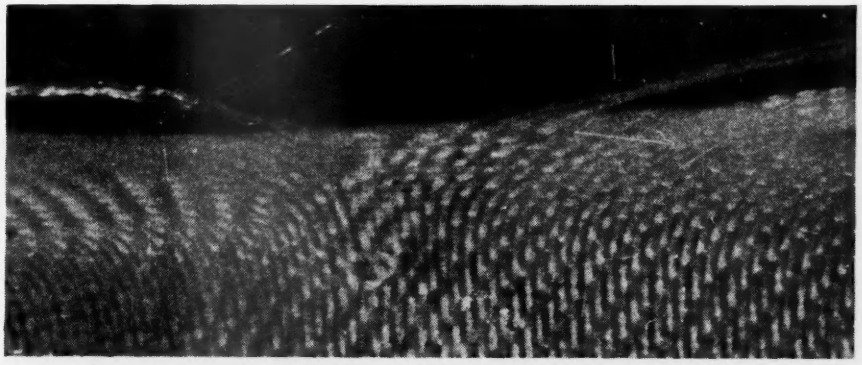

FIG. 3. *Photograph of del-shaped opening under 2,000-gram load.*

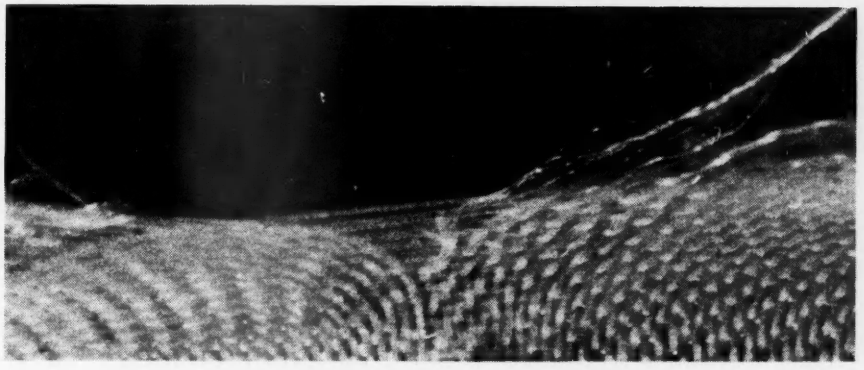

FIG. 4. *Photograph of re-formed effective jaw after break.*

TABLE I. FREQUENCY ANALYSIS FOR TEAR TESTS ACROSS WARP AND FILLING

Fabric count (picks/in.)	Frequency Maxima per 3 in. on chart Across warp (mean)	Across filling (mean)	No. of tests Warp or filling
160	8.6	7.2	5
150	9.2	8.2	5
140	8.4	8.2	5
130	8.2	7.6	5
120	7.4	7.4	5
100	6.6	5.8	5
70	5.2	4.8	5
50	Filling failure	3.0	5

strengths of the samples were determined and correlated with fabric count.

The strength was determined by a process of averaging maximum load points weighted by the extension over which they act—that is, a reading is taken for each maximum point on the chart, and for the distance between it and the succeeding maximum, along the extension axis. These two readings are multiplied together, their products added, and the sum divided by the total distance between first and last maxima, which gives an average maximum load value.

Conclusions

Case A—Frequency Analysis. Table I shows the results of a frequency determination for tear tests when testing is done across the warp and across the filling.

An analysis of variance of the data in Table I for testing across the warp yields Table II.

At the 1 percent level the critical F [6] for these degrees of freedom is 3.53, so that the means in Table I are significantly different. Thus we can perform a correlation analysis [5] on the data. Such an analysis yields a coefficient of correlation (r) of 0.96, which is highly significant.

A regression analysis [5] shows that, for this case:

$$y = 0.043\ x + 2.4,$$

where y = waves per 3 inches on chart
and x = picks/inch.

(See Figure 5.)

A similar analysis of frequency of breaks for the fabrics tested across the filling (data in Table I) yields an analysis of variance (Table III), as in Table II.

TABLE II. ANALYSIS OF VARIANCE [5] FOR TESTS ACROSS WARP

Source of variation	Sum of squares	°F	Estimated mean square variance	F
Among means	45.04	6	7.51	6.76
Within means	31.20	28	1.11	—
Total	76.24	34	—	—

TABLE III. ANALYSIS OF VARIANCE FOR TESTS ACROSS FILLING

Source of variation	Sum of squares	°F	Estimated mean square variance	F
Among means	115.56	7	16.51	13.5
Within means	39.08	32	1.22	—
Total	154.64	39	—	—

At the 1 percent level the critical F in this case is 3.25, so that the differences among means are highly significant. A correlation analysis yields $r = 0.94$, which is highly significant, and a regression line:

$$y = 0.043\ x + 1.6.$$

(See Figure 6.)

The results of this frequency analysis can be shown to be in agreement with the pseudo jaw hypothesis. For, on the basis of this hypothesis, as the fabric count in either direction is increased, more yarn contacts occur, friction forces build up more rapidly, and the pseudo jaw forms more quickly. Therefore if tests are run at a given speed, a larger number of yarn groupings to form jaws should occur in a given length of tear. In terms of the tear-

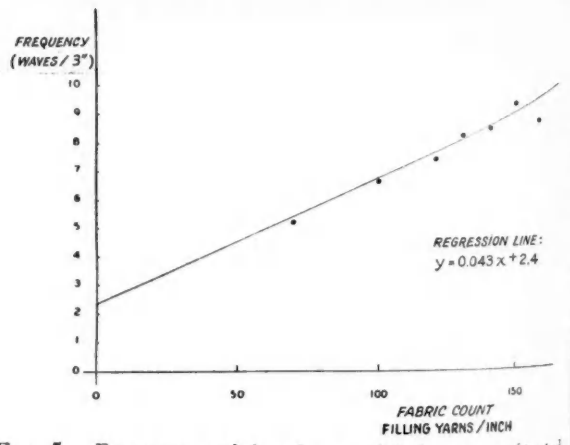

FIG. 5. *Frequency of breaks vs. fabric count (tested across the warp).*

TABLE IV. TEAR STRENGTH ACROSS THE WARP

Fabric count (picks/in.)	Tearing strength (mean in lbs.)	No. of tests
160	3.74	5
150	3.90	5
140	3.93	5
130	4.12	5
120	4.26	5
100	4.60	5
70	5.13	5
50	Failed in other direction	

TABLE V. ANALYSIS OF VARIANCE FOR TESTS ACROSS WARP

Source of variation	Sum of square	Degrees of freedom °F	Estimate of variance	F
Among means	6.55	6	1.08	67
Within means	0.46	28	0.016	—
Total	7.01	34	—	—

test diagram, this should result in more rapid cycling, and the frequency of maxima should increase with increase in fabric count. And the direction of tear should not influence this relationship. As can be seen from Figures 5 and 6, the experimental data are in accord with this prediction in both directions of test, and the slope of the regression line is about the same in both cases.

Class B—Strength Analysis. In calculating tear strength the method used involved calculating the weighted maxima, as discussed earlier in this paper. Table V shows the analysis of variance for tests run across the warp (data in Table IV).

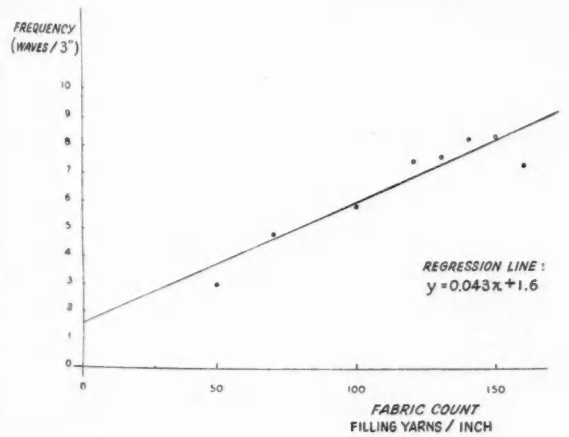

FIG. 6. *Frequency of breaks vs. fabric count (tested across the filling).*

TABLE VI. TEAR STRENGTH ACROSS THE FILLING

Fabric count (picks/in.)	Tearing strength (mean in lbs.)	No. of tests
160	3.86	5
150	3.82	5
140	3.86	5
130	3.90	5
120	3.87	5
100	4.00	5
70	3.95	5
50	4.50	5

TABLE VII. ANALYSIS OF VARIANCE FOR TESTS ACROSS FILLING

Source of variation	Sum of squares	°F	2	F
Among means	1.75	7	0.25	9.3
Within means	0.87	32	0.027	—
Total	2.62	39	—	—

The critical F at the 1 percent level is 3.53. Therefore, it may be concluded that the means differ significantly among themselves—that is, the mean tearing strength varies with fabric count, the variation being greater than that which would result from sampling fluctuations alone. Applying a correlation analysis, the calculation yields a coefficient of correlation of — 0.95, which shows a highly significant negative correlation.

The regression line is found to be:

$$y = 5.83 - 0.013\,x,$$

where y = strength in pounds
and x = picks per inch.

(See Figure 7.)

Testing across the filling and performing an analysis of variance on the resultant strength data (in Table VI) yields Table VII.

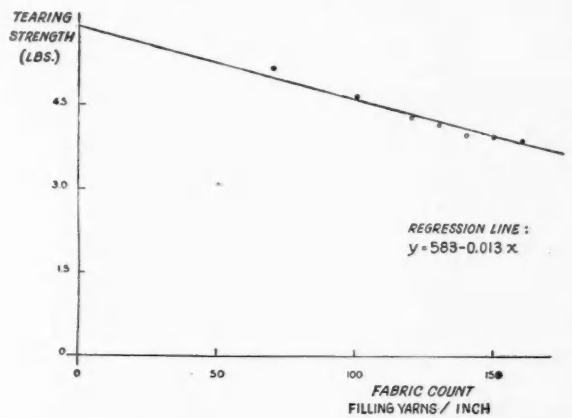

FIG. 7. *Tearing strength vs. fabric count (tested across the warp).*

The critical F at 1 percent is 3.25, so that the differences among means are significant. A significant correlation coefficient (— 0.83) is obtained and the regression line is found to be:

$$y = 4.65 - 0.005\,x,$$

where y = strength in pounds
and x = picks per inch.

(See Figure 8.)

Again, from the hypothesis, in testing across the warp as the filling count increases, crowding of yarns occurs more rapidly and a jaw of smaller width is formed. But as the density of warp yarns remains constant this means that fewer yarns are stressed. Thus a lower load will cause failure of the jaw, and the maxima will be lower for higher fillingwise fabric count. Thus the hypothesis calls for a negative regression, which is checked by the experimental data.

In testing across the filling, on the other hand, as the density of picks increases a jaw is built up more rapidly, and consequently one of small width is formed. In this case, however, there are more yarns per inch in the jaw, so that the actual number of yarns stressed remains the same. The theory thus indicates a horizontal regression line.

This is not quite realized experimentally, probably for the following reasons:

1. The yarns held in the pseudo jaw do not all rupture at once but have elements of progressive failure as units or in groups, in their behavior.

2. As the count increases, yarns are crowded together, which tends to decrease the area of contact and so to decrease friction effects.

3. If only n friction points are needed to hold the crosswise yarns firmly enough to cause their rupture on further loading (that is, to form the "effective" jaws) the presence of more than n such points cannot build up an effect on the result, as all points other than these n ones will have an effect on the "pseudo jaws," but not on the "effective jaws." This difference between the "pseudo" and the "effective" jaws is well illustrated in the grab test for tensile strength. In that test the "pseudo jaws" extend over the whole width of the fabric, whereas the effective jaws lie within the area between the 1-inch jaws. It is therefore possible for the regression line to deviate somewhat from the horizontal. Experimentally we find a regression line of negative slope but, as is called for by the hypothesis, the slope is considerably less than in testing across the warp.

When a tongue-tear test is conducted on a specimen and an autographic chart diagram is thus obtained it will be noted, in general, that the load required to tear the specimen fluctuates between suc-

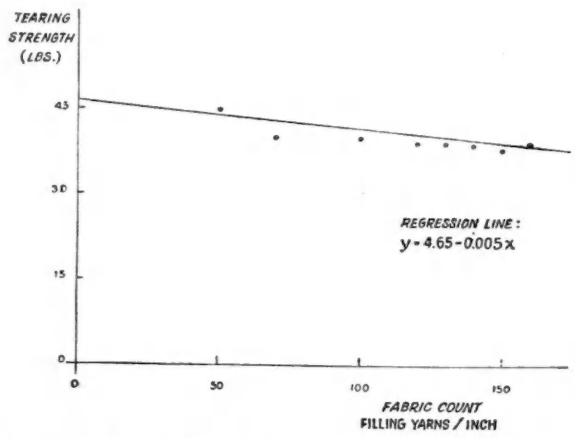

FIG. 8. *Tearing strength vs. fabric count (tested across the filling).*

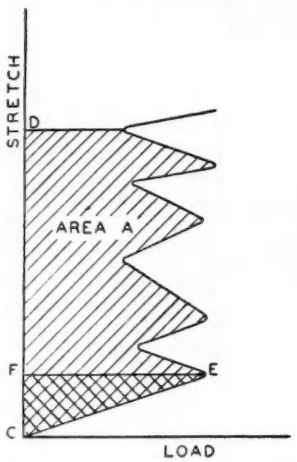

FIG. 9. *Typical tear-test diagram illustrating the area representing energy expended.*

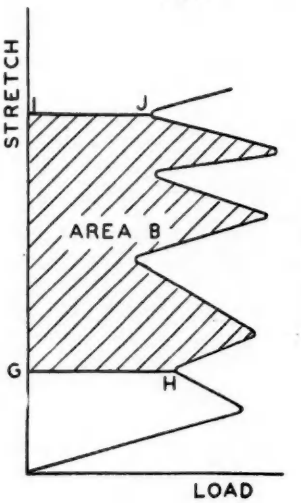

FIG. 10. *Typical tear-test diagram showing energy expended with correction for energy expended to stretch sample.*

cessive maximum and minimum values. The A.S.T.M. specifications give the following procedure for evaluating these diagrams: "The machine shall be started and the average load necessary to tear the fabric shall be observed, preferably by means of an autographic recording device."

What is meant by "average tear" or the method of finding this average is not given. It is even assumed that this average can be reported without reference to an autographic recording device. In actuality the fluctuations in load are so rapid that they do not permit any quantitative measurement of average tearing strength. Thus an autographic attachment is not just preferable but necessary. As will also be seen from the ensuing discussion, many complications arise in measuring this average.

Methods of Interpreting Tear-Test Diagrams

Energy Evaluations. Figure 9 shows a typical load-stretch curve for a tongue-tear test. One method of finding the average tear strength is to find the shaded area A, by use of a planimeter or some allied method, and to divide this area by the length CD. The result is a value for the average abscissa, representing load, and therefore gives a value for the average tearing strength. There is one possible serious error in such a method. The first break E might occur in two different samples at the same load, but in one case at a high extension and in the other at a low extension. In one case, therefore, the cross-shaded area CEF may be small and in the other it may be large; and this area, when added to the total area, would have very different results on the average tearing strength in the two cases. But this area represents only the energy necessary to stretch the fabric to the tearing point and should not enter into a calculation of tearing strength. Thus area B in Figure 10 is a better area to use, where GH is drawn parallel with the load axis and at some extension higher than that at which the first break occurs. This area B should be divided by the length GI to give the average tearing strength.

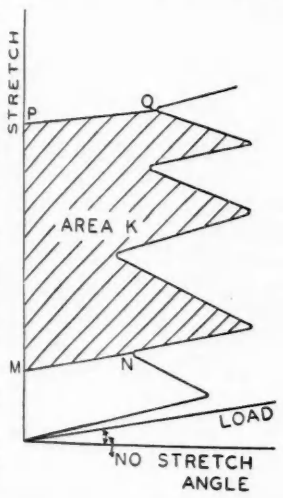

FIG. 11. *Typical tear-test diagram showing no stretch angle corrections for energies.*

The above arguments are made for a machine with a loading jaw travel correction, but hold equally well for a machine without such correction, except that here the axes are not at right angles and the area K (Figure 11) must be found, the lines MN, PQ being drawn parallel with the load axis. The area should be divided by MP to give an average tearing strength.

Averaging Minima. It has been suggested that an average of the minimum points be used in order to give a higher factor of safety in determining the breaking strength of any fabric. The experiments of this investigation, however, indicate that the breaks actually occur at the maximum points, and that the minimum points occur at the end of a period during which the fabric takes up the slack left by previous breaks. Thus the minima do not in any way represent breaking loads. In a fabric of high yarn strength the maxima would occur at high loads, but if the yarns were slippery so as to allow considerable slippage before an "effective" jaw is built up, the minima would occur at low loads, and would be far away from the actual breaking loads. The most desirable result is one reasonably close to the actual tearing strength, and so, although the method of averaging minima gives a high factor of safety, it is likely to give a value at variance with the actual tearing strength. The minimum values are also much more dependent upon the rate of load than the maxima, because these values are dependent upon the speed with which friction forces are created.

Averaging Maxima. The method of averaging maxima would appear, on the basis of the present investigation, to be the most desirable method. The breaks actually do occur at these maximum points, so that if a load equal to that calculated as average either from averaging minima or from energy evaluation were applied to the fabric it would not break. The possible, but unlikely, exception is the case in which the first maximum occurs below the average load computed by either of the above methods. In this instance the fabric will begin to tear but will not continue to do so unless the second peak is also below this computed average.

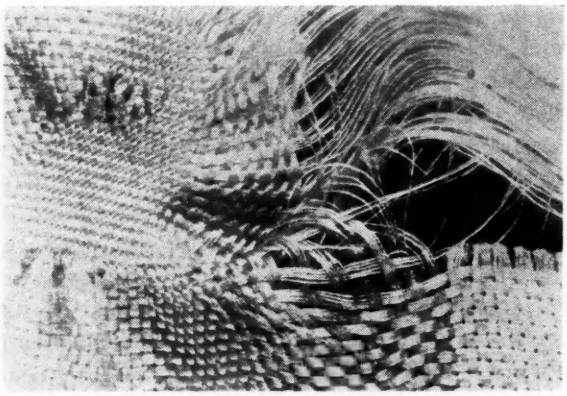

FIG. 12. *Photograph of 5 × 5 basket weave showing damage due to slippage, but no tearing.*

If, conversely, the first maximum point were higher than the load obtained by averaging maxima, the fabric would not begin to tear even when what was considered the average tearing load was impressed on it. When the first maximum point is below the average of the maxima, the fabric will fail. Thus the value of tearing strength found by averaging maxima is sometimes a little too low and sometimes a little too high, but such an average tearing strength is the closest available approximation to the load which will actually tear the fabric.

Methods of Increasing Fabric Tear Strength as Measured in the Tongue-Tear Test

There are essentially three ways to increase the tear strength as recorded in a tongue-tear test when a fabric is tested across warp or filling.

The first method is to decrease the fabric count in the other direction from that which is being tested. This results in fewer friction points being formed, and consequently results in a wider "pseudo" jaw. This wider jaw then contains more yarns to take the load and so the strength goes up. The tear strength, in the direction in which the fabric count is lowered, is either not decreased at all or decreased only slightly, as shown previously in this report (Figure 8).

The second method consists in keeping the fabric count constant but in using yarns with higher tensile strengths in the direction across which the tear strength is to be tested. This method can be used in conjunction with the method of changing fabric count; for example, in the direction in which fabric count is lowered above, stronger yarns could be used to restore any possible small drop in tearing strength.

The third method is to increase the tearing strength by decreasing the friction effects in the fabric, either by using more slippery yarns or longer floats in the weave. It will be seen from the photograph of the results of a tear test run on a 5-by-5 basket weave balloon fabric (Figure 12) that if the floats are lengthened sufficiently the fabric will not tear at all. However, in this case, the increase in tear strength is of little use because the fabric is damaged by slippage as much as it would be by tearing. There is probably a most efficient float length, depending on the yarn characteristics, which has the highest tearing strength and the lowest damage due to slippage.

All three methods can be used in conjunction to obtain a fabric with approximately equal tearing strengths in both directions tested, but also with higher tearing strengths than were previously obtained.

It is also important to state that all these methods seem to have points of optimum efficiency below or above which the results are less and less desirable. It is obvious, for example, that we can lower fabric count so much that the fabric will come apart without tearing. The existence of this optimum point in the case of floats has already been demonstrated. These optimum points depend upon yarn and fabric characteristics and must be determined for each fabric tested. With knowledge of these optimum points and the general laws stated above, it should be possible to get higher, better-balanced tearing strengths in fabrics for which these conclusions hold.

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Effect of Tire Cord Uniformity on the Strength of Tire Fabrics

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The strength of tire fabrics, which largely determines tire carcass strength, is dependent not only upon the average strength of the tire cords of which the fabric is made but also upon their uniformity. The degree of uniformity can be measured by the coefficient of variation of strength and of elongation, but such data do not, by themselves, show directly the influence of tire cord uniformity on fabric strength. Various methods of estimating the effective strength of tire cord are discussed. A formula is presented which permits a simple calculation of the effective cord strength from the coefficient of variation of cord strength. The various methods show a satisfactory degree of correlation. The effective cord strength of several rayon and cotton tire cords has been calculated.

THE cord fabric used in the carcass of automobile tires differs from most ordinary fabrics chiefly in one respect: it possesses strength either entirely or almost exclusively in only one direction—namely, parallel with the lay of the tire cords composing it. In the crosswise direction the cords may be held together by weak filling yarns, spaced widely apart, which are just strong enough to hold the cords in place during the calendering operation; or the cords may be calendered directly from a creel. These filling yarns, if they are present, are expected to break either before or soon after the tire is put into service. The strength of the tire fabric, which largely determines carcass strength, is therefore dependent exclusively upon the tensile strength and stretch characteristics of the cords making up the fabric.

One commonly used method of estimating the strength of the carcass is to multiply the average single-cord strength by the number of cords per inch in each ply and to add these figures together to obtain an index of the total carcass strength. Such an estimate is based upon the assumption that the cords possess the same strength in the tire fabric that they show when broken individually. It is generally recognized, however, that the effective strength of the cord in the fabric depends not only upon the average strength of the cord but also upon its uniformity. As a measure of uniformity the spread of the traces on the load-elongation charts and the range of strength and elongation values have been employed in routine measurements. For more exact comparisons the coefficient of variation of the strength readings has been used. However, it has not been possible to evaluate the effect of a given degree of non-uniformity on the strength of the tire-cord fabric, or to express the difference in uniformity of two different cords in terms of carcass strength.

With the advent of new industrial fibers such as rayon and nylon, in the tire-cord field attention is focused on this factor of uniformity because some of the new synthetic tire cords may have a different degree of uniformity from that of the cotton cords heretofore used in tires. Accordingly, it becomes more important than ever to be able to evaluate the influence on tire-cord fabrics of varying degrees of cord uniformity. In the present study an attempt is made to determine quantitatively the maximum strength which the cords, otherwise ideally disposed, may be expected to show in the fabric. This strength, which may be called "effective cord strength," may be expressed as a percentage of the average single-cord strength. Thus the effective cord strength indicates what percentage of the average cord strength can be utilized in a fabric, and

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TABLE I. STRENGTH AND ELONGATION OF SEVERAL RAYON AND COTTON TIRE CORDS AND THEIR COEFFICIENTS OF VARIATION

	Cord No.	Strength		Elongation at 10 lbs.		Ultimate elongation	
		Mean (lbs.)	Coefficient of variation (%)	Mean (%)	Coefficient of variation (%)	Mean (%)	Coefficient of variation (%)
Rayon	R–1	11.56	2.31	13.95	2.29	16.16	2.46
	R–2	12.40	3.26	11.01	3.64	13.69	4.90
	R–3	11.48	2.54	18.19	2.86	20.78	2.66
	R–4	11.75	2.81	12.17	2.74	14.28	2.80
	R–5	11.75	3.10	11.69	4.08	13.96	3.80
	R–6	11.03	2.61	13.14	3.76	14.89	2.81
	R–7	12.92	2.05	10.34	4.21	14.25	3.58
Cotton	CC–8	23.78	3.51	5.04	3.07	9.81	3.34
	CC–9	21.12	4.26	5.01	3.22	9.51	4.60
	CC–10	21.12	3.63	9.04	5.77	14.55	4.62
	CC–11	19.73	3.70	7.12	4.64	10.91	4.64
	CC–12	14.36	5.53	4.89	2.51	6.53	5.28
	CL–13	14.80	5.16	13.44	2.90	16.95	3.76
	CL–14	17.33	3.86	13.77	3.87	18.85	3.81
	CL–15	17.30	4.13	9.34	3.27	13.67	2.66
	CL–16	19.26	3.75	13.53	3.47	19.03	2.89
	CL–17	21.65	4.64	15.43	3.01	22.21	3.40

provides a means for comparing the strength of different tire cords of different degrees of uniformity.

Materials

The tire cords employed in the present study consisted of ten different cotton and seven rayon cords. The rayon cords were all commercial, continuous-filament products, identified by the reference numbers R-1 to R-7. The cotton cords fall into two groups. Five cords, referred to below as CC-8 to CC-12, were of commercial origin, whereas the other five cords, identified by the reference numbers CL-13 to CL-17, were made at this Laboratory on conventional textile machines, without subsequent stretching. The breaking strengths of the tire cords and their elongations at 10 pounds and at break are listed in Table I, together with their coefficients of variation. These data represent means, based on 100 individual measurements each, performed under standard conditions of temperature (70° F) and humidity (relative humidity 65 percent) on a Scott tire-cord tester, in accordance with A.S.T.M. [1] specifications for testing tire cord.

Calculation of Fabric Strength from Cord Load-Elongation Curves

In order to calculate the strength of a fabric composed of parallel tire cords of different strength and stretch, one may consider what happens when a load is applied to such a structure. Since the mechanical characteristics of the individual cords are not the same, the total load is not evenly distributed among all the cords. Each cord supports a load determined by its individual load-elongation curve. As the total load on the fabric is progressively increased, an elongation equal to the lowest ultimate elongation of the cords in the fabric will be reached. This will lead to rupture of the first cord. Without increase of the total load there will be a redistribution with increase of the load carried by the remaining cords. As the total load is further increased, more and more cords will be broken, until the remaining cords can no longer support the total load. At this point the structure fails. The maximum load supported by the fabric at this moment is equal to the breaking strength of the fabric. It is less than the product of the mean strength and the number of cords. These considerations, applied to a representative number of tire cords of which a particular fabric is made up, permit an estimation of the expected fabric strength.

In this connection it is interesting to note that Brown, Mann, and Peirce [2] have carried out similar calculations for the maximum realizable fiber strength in a cotton yarn, using fifty fiber load-elongation curves each for five different cottons. They found that, on the average, because of the fiber variability alone, not more than 47 percent of the single-fiber strength could be utilized in a yarn.

TABLE II. EFFECTIVE CORD STRENGTH ESTIMATED BY DIFFERENT METHODS

Cord No.	Coefficient of variation of strength (%)	Effective cord strength, in percent of average cord strength, calculated from: 20 load-elongation curves	100 actual breaks (equation 1)	1,000 theoretical "normally distributed" breaks (equation 1) or from coefficient of variation (equation 2)	Determined by serigraph group tests
R-7	2.05	96	95	94	—
R-1	2.31	96	96	94	97
R-3	2.54	92	93	93	97
R-6	2.61	94	92	93	96
R-4	2.81	96	94	92	98
R-5	3.10	92	94	92	97
R-2	3.26	97	93	92	94
CC-8	3.51	97	92	91	—
CC-10	3.63	90	92	91	85
CC-11	3.70	95	91	91	88
CL-16	3.75	91	89	90	88
CL-14	3.86	92	92	90	91
CL-15	4.13	88	91	90	88
CC-9	4.26	94	90	90	87
CL-17	4.64	89	88	89	90
CL-13	5.16	85	89	88	90
CC-12	5.53	87	89	87	90

Actually, not even this percentage is reached in cotton yarns because of other factors such as spiral structure, incomplete "tying-in" of fibers, imperfect yarn structure, etc. [2, 3]. Similarly, in a tire there are certainly other factors aside from non-uniformity of the cords which will have an effect on fabric strength, so that "effective cord strength" data are to be considered maximum rather than actual values.

This very laborious and cumbersome procedure was employed for the calculation of the effective strength of fabrics made from the seventeen cords described in Table I. Twenty load-elongation curves were picked at random from the hundred curves available for each cord. If the fabric had consisted of these twenty cords only, the cord with the lowest ultimate elongation would have been the first to break. Hence, the lowest ultimate elongation was determined, and the load carried by each of the remaining cords at this elongation was read from its load-elongation graph and the loads were totaled. This procedure was then repeated with an elongation equal to the next lowest ultimate elongation, and so on until the maximum load was found. This maximum load divided by the number of cords in the fabric and expressed as percentage of the average single-cord strength gave the effective cord strength. The results of these computations are shown in the third column of Table II. The effective strength of tire cords in a fabric, it may be seen, is considerably greater than the effective strength of cotton fibers in a yarn.

This method is very time-consuming and must, therefore, be restricted to a relatively small number of load-elongation curves, which greatly reduces the accuracy of the estimate. Furthermore, in order to be able to read the load carried by a tire cord from its load-elongation charts, several graphs must not be superimposed on the same chart, as is customary in ordinary tensile testing. This further complicates this method.

Calculation of Fabric Strength from Tire-Cord Strength Data

Another approach to the problem may be to calculate the effective cord strength under the assumption, as a first approximation, that when subjected to a load the cords in a fabric break in the order of increasing breaking strength, and not in the order of increasing ultimate elongation. Strictly speaking, this is the case only when all the cords in the tire fabric follow the same load-elongation curve and differ only in the end-point of the curve. In that case there would be a perfect correlation between the coefficient of variation of strength and that of ultimate elongation. Actually, the curves for different specimens of the same cord do not deviate from this

requirement too much, and, in the case of the seventeen tire cords examined in this test, the correlation coefficient between the two coefficients of variation was found to have the value of 0.50, which is statistically significant.

Therefore, in this procedure the load-elongation curves of a representative number of tire cords are not arranged according to their ultimate elongation but according to their breaking strength, and the maximum realizable strength of the aggregate is calculated by assuming that the first cord to break is the weakest one and that the load is evenly distributed among the surviving cords. The total load carried by the fabric after a certain number of cords have broken is then equal to the breaking load of the last cord which broke multiplied by the number of surviving cords. If the cords are given numbers in the order of decreasing strength, each cord is characterized by an order number n and a breaking strength S_n. The order number n, it will be noted, gives the number of cords capable of supporting the load S_n. The load carried by the fabric after a certain number of cords have broken is then equal to the product of the order number and the breaking strength of the last cord that broke. Therefore, the maximum of this product, $(n.S_n)_{max}$, gives the strength of the fabric, and $(n.S_n)_{max}/N$ is the effective strength of the cords in the fabric, if N is the total number of cords in the fabric. Expressed as a percentage of the average single-cord strength $\bar{S}$, the effective cord strength E is then

$$E = \frac{100\ (n.S_n)_{max}}{N.\bar{S}}. \qquad (1)$$

This idea was first applied to the calculation of the influence of fiber uniformity on yarn strength by Turner [3]. In four samples of cotton, representing two varieties, he found the maximum effective fiber strength in a yarn to be only 50 percent of the average single-fiber strength, as determined from 1,000 single-fiber breaks each. This is in good agreement with the value obtained by Brown, Mann, and Peirce [2] with the aid of actual load-elongation curves.

Equation (1) was applied to the seventeen tire cords for which 100 breaks each were available, with the results shown in column 4 of Table II. In this table the seventeen samples of tire cord are arranged in the order of increasing coefficient of variation of strength, and it may be seen that there is a general trend for the calculated fabric strength to decrease as the degree of uniformity decreases. Also, there is good agreement with the values in column 3 obtained by the first method. This is further shown by Figure 1, in which the effective cord strength, as determined by both methods, is plotted as a function of the coefficient of variation of cord strength.

Calculation of Effective Cord Strength from Coefficient of Variation of Strength

Contrary to that of single fibers, the strength of tire cords from a given sample approaches very closely a normal distribution. Therefore, instead of using actual cord strength data, it is possible to perform the calculations with a set of theoretical values taken from a normal frequency distribution and arrayed in the same way as were the 100 actual strength data used for application of equation (1). Since the normal distribution is based on an infinite population, this treatment has the advantage of generalizing the results. Such an arrayed distribution is commonly known as a cumulative frequency distribution and the magnitude of the "strength" value at any desired order number can be obtained readily from tables of areas of the normal curve. The tables usually give the normal distribution for a standard deviation of 1 and a mean of 0, but values for any other desired standard deviation and mean can easily be computed by well-known methods. The cumulative frequencies—that is, the areas of the normal curve from any particular "strength" value to infinity— correspond to the order numbers. To carry out the operation called for in equation (1), the maximum for the product of the normally distributed "strength" values and their cumulative frequencies was determined, taking 100 as the mean "strength"

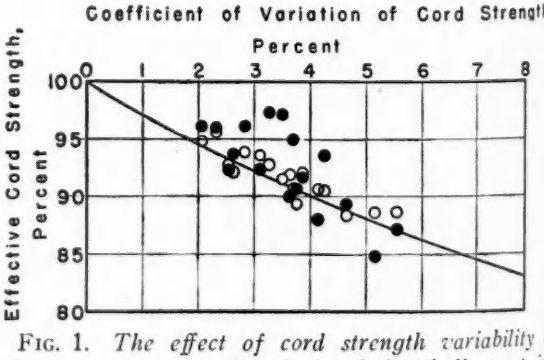

FIG. 1. *The effect of cord strength variability on effective cord strength. Open circles indicate points calculated from 100 actual strength measurements; full circles are calculated from 20 load-elongation diagrams; the curve from 1,000 "normally distributed" theoretical strength data.*

so that the standard deviation and the coefficient of variation had the same numerical value. Maxima were computed for distributions, with coefficients of variation ranging from 0 to 10 percent, and for the seventeen coefficients of variation in column 2 of Table II. The results, listed in column 5, are in good agreement with those in columns 3 and 4.

All the data on effective cord strength obtained by application of formula (1) to normally distributed values are represented by the curve in Figure 1. Any discrepancies between the data obtained on 100 actual breaks and this curve are considered to be due partly to deviations of the distribution of the 100 breaks from normal distribution and partly to difference in sample size. In the latter respect this curve is probably an even better estimation of effective cord strength than the values based on 100 actual breaks.

The function relating effective cord strength with the coefficient of variation of cord strength could, of course, be derived from equation (1) and the equation of the normal frequency curve. Unfortunately, this leads to complicated expressions, for which the solution can only be approximated. However, since solutions for specific coefficients of variation up to 10 percent have already been obtained, it is possible to approximate the function by an empirical equation. By variously plotting the data for E (from Table II, column 5) as a function of the coefficient of variation of strength V (from Table II, column 2) it was found that an almost straight line is obtained when $1/E$ is plotted as a function of V. Evaluation of the constants and rearrangement lead to the equation

$$E = \frac{100}{1.01 + 0.025V}. \qquad (2)$$

This equation was found to give good agreement with effective cord strength data computed by application of equation (1) to an array of normally distributed values, over a wide range of coefficients of variation.

Since the coefficient of variation can easily be computed from a series of strength data obtained by the usual method of measuring tire cord strength, it is a simple matter to estimate the maximum strength which any sample of tire cord would exhibit when woven into a tire fabric, either by the use of equation (2) or from Figure 1.

Experimental Determination of Effective Cord Strength

In addition to the above-described methods of calculating effective cord strength, the possibility of an experimental determination also has to be considered. An experimental determination of effective cord strength would require simultaneous breaking of a large number of parallel cords which are all under uniform initial tension and are not allowed to slip. This is a requirement which is very difficult to fulfill experimentally. The problem is similar to that encountered in the group testing of single yarns by the skein test or by the serigraph group test. Of these two methods, the serigraph test described by Haven [4] is definitely superior as a group test. Although it was realized that this test has many shortcomings, it was applied to fifteen of the seventeen tire cords because of its relative simplicity.

The tire cord to be tested was wrapped around a yarn-appearance board at a fairly constant tension by means of a Suter Yarn Evenness Controller of the type commonly used for preparation of yarn-appearance boards. When 40 ends had been laid side by side their relative positions were fixed by strips of Scotch drafting tape, spaced 10 inches apart, and the specimen was carefully removed from the appearance board by cutting the cords beyond the adhesive tape. The specimens prepared in this way were then placed between the fabric jaws of a Scott horizontal tester of 800-pound capacity, care being taken that the cords were all held under as nearly uniform tension as possible and were as nearly parallel as possible to the direction of pull. These conditions are difficult to attain, and this constitutes one of the main weaknesses of the test as applied to this problem. The distance between jaws was 10 inches in order that the data would be comparable with those obtained on single cords. Ten specimens each were broken and the effective cord strength, computed from the means, is shown in the last column of Table II. Agreement with the data obtained by the other methods is not very good. It may be noted, however, that despite the many imperfections of the experimental method there exists a definite relationship between the data obtained by the serigraph method and those calculated from equation (2), as well as those calculated from cord load-elongation curves. This is indicated by a correlation coefficient of 0.71 between the effective cord-strength data obtained experimentally and those calculated from equation (2) and by a correlation coefficient of 0.51 between the former and the data obtained from load-

elongation curves. Both correlations are statistically significant, 0.71 being highly significant.

Discussion of Results

Of the different methods which permit an estimation of the effective strength of tire cord, equation (2) is obviously the simplest. With the aid of this formula the effective cord strength can be calculated from the strength data usually obtained in the determination of average cord strength. It must be remembered, however, that this equation is based on the same assumption as equation (1)—namely, that the cords in a fabric break in the order of their breaking strength rather than their ultimate elongation, which assumption is only approximately fulfilled. However, agreement between data obtained by this method and by calculations based on actual load-elongation curves (Table II, columns 5 and 3) is satisfactory, the correlation coefficient being 0.75. The latter method is fundamentally the best method, but its disadvantage is its extremely cumbersome procedure, especially when applied to a relatively large number of load-elongation curves. However, if the number of curves employed is limited, the precision of the result is reduced, and the theoretical advantage of this method is therefore lost. An estimation of effective cord strength by the use of equation (1) on a representative number of tire-cord strength readings has no advantage over that obtained by use of equation (2), except when there is a definite departure of the strength readings from a normal distribution. The method is also more time-consuming. In general the application of equation (2) will probably provide the more useful method.

The direct experimental method, while theoretically simple, would be useful only in the determination of effective cord strength if considerable improvements were made in the serigraph technique. Despite its experimental imperfections, the data obtained by the serigraph test show a definite relationship between the direct experimental method and the theoretical methods. Although the serigraph group test, as employed in the experiments described here, does not seem to furnish a reliable estimate of effective cord strength, the positive correlations indicated above lend support to the theoretical methods. With an improvement in experimental technique these correlations may be further improved.

Obviously, any of the above methods of calculating the effective strength of a tire cord in a tire fabric takes into consideration only the influence of uniformity. Other factors, such as non-uniform tension of the cords in the fabric, the distribution of stress in the different plies of the tire, adhesion of the cords to rubber, etc., will also affect the realizable single-cord strength, but they do not originate in the tire cord and can be controlled to some extent. It is also realized that in a tire carcass breaks occur under conditions which are different from those in a Scott tester. However, it is reasonable to expect that the influence of these conditions will be roughly the same for any tire cord, no matter what its variability. The uniformity of the tire cord is an inherent cord property and should be included in any estimation of fabric strength.

It is suggested that effective cord strength rather than average single-cord strength be used in the computation of the index of tire carcass strength. The most convenient method of estimating effective cord strength at this time is by means of equation (2). For example, the index of carcass strength of a 6-ply tire with 30 cords per inch made from a cord of 15 pounds' breaking strength is considered to be lower than that of a similar tire made with cords of 16 pounds' strength—namely, 2,700 pounds as against 2,880 pounds. If, however, their respective coefficients of uniformity of strength are 2 and 6 percent, then, according to formula (2), the cord with a breaking strength of 15 pounds has an effective strength of 14.2 pounds, whereas that with a breaking strength of 16 pounds has an effective strength of only 13.8 pounds. The index of carcass strength of the two tires should be computed to 2,560 and 2,480 pounds, respectively; that is, the strength relation between the two is reversed.*

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A Study of the Pressley Cotton Fiber Strength Tester*

Simon Williams and E. V. Painter

Summary

1. With a very homogeneous sample (a single length group) the Pressley Tester reliably distinguished between a difference of 0.5 Index with 10 breaks, including variations between two machines and two operators. Under conditions making for more variable samples, this difference should be regarded as a minimum value.

2. A difference of 0.27 ± 0.08 Index was found between two typical machines and a 0.15 ± 0.07 Index difference was found between two experienced operators on the same machine. With a large number of samples (30 or more) these differences are significant, but they fall within normal sample variation for only 10 breaks.

3. Analysis of 120 breaks from a single length group from a bale sample of a single variety of cotton indicated that the Pressley Indices obtained did not come up to calculated accuracy. This indicated that the individual values were not normally distributed. An eccentricity of cotton sampling often encountered in this and other fiber tests is proposed to explain this anomaly—namely, that small groups of fibers representing some common point of origin seem to persist in highly localized clusters. This phenomenon has been labeled a "concentration effect."

4. A study of various bundle widths indicated a decrease of approximately 1.0 Index (13 percent) as the bundle was widened from ⅛ inch to ½ inch. It was further shown by this study that wider bundles emphasized machine eccentricities and data variability. It is suggested as a remedy, therefore, that a standard width within narrow limits be established. It is felt that ultimately a redesign of the jaws and jaw supports will be necessary to increase the precision of the test and the reliability of any one machine.

5. A number of further possible sources of error were investigated and, while certain definite differences were indicated, on the whole the variations due to these sources were within the limits discussed in paragraph 1 above. These possible sources of error were:

(*a*) Various jaw pressures on the bundle of cotton, arising from various values of measured torque applied to the jaw screws.
(*b*) Various bundle weights, within the range normally encountered.
(*c*) Various degrees of misalignment of the bundle (that is, "bundle angle").
(*d*) Time of day at which tests were made.
(*e*) Worn jaw screws.

6. Finally, it seems highly advisable from the results obtained in this study *not* to rely upon data obtained from one machine alone. Constant reference should be made to other machines through a uniform "check cotton," or, better still, by making half the breaks within a test on one machine and half on another, with a constant reference to a "check" cotton. Thus it becomes much simpler to determine exactly when a particular machine begins to give erratic results, indicating the necessity for a complete checkup on the working parts to remove the source of trouble.

Experimental Procedure

Since its announcement in 1942 [1], the Pressley Cotton Fiber Strength Tester has largely replaced the Modified Chandler Bundle Test as a method of evaluating the relative fiber strengths of various cottons by virtue of being simpler and more rapid.

However, after making thousands of tests in this laboratory during the course of the past two years, it was found impossible to duplicate the accuracy of results noted by Pressley [1]. Furthermore, it was found that the techniques employed in utilizing the Pressley Tester varied widely in the different laboratories of the country, and that confusion and uncertainty had developed regarding the accuracy of

* A contribution of the Research Division, National Cotton Council of America, in affiliation with The Bureau of Industrial Chemistry at The University of Texas, Austin, Texas.

the test. Eccentricities in test data have been variously attributed to machine design, operator differences, machine differences as affected by the leather in the jaws, jaw-screw pressure, bundle weight and shape, etc.

In an effort to evaluate some of these variables, and to permit the further use of the tester without necessitating its redesign, the data reported below were accumulated. They are in no sense complete and refer only to the machines in use in the laboratories of the National Cotton Council. However, these data permit certain conclusions of sufficient general interest to be called to the attention of the laboratories working with cotton fibers. It is hoped that they will be of value in determining whether or not to recommend adoption of the Pressley Test as a standard.

Description of the Tester

For those unacquainted with the Pressley Tester, a standard model is shown in Figure 1. A brief description of the parts and their use follows, but for complete details reference should be made to Dr. Pressley's article [1].

Referring to the numbers in Figure 1, a typical "break" is made as follows:

A pinch of cotton (*2*, left) is combed on the small comb at the base of the jaw holder (*1*), and then placed in the jaws. The tops of the jaws are closed and the screws tightened. The jaws are removed from the holder and all cotton protruding from either side is trimmed with the knife (*3*, left). The jaws are held together by the bundle. After trimming, the jaws are inserted in the supports at (*4*). The sliding weight (*5*) is released and allowed to travel down the track (which is adjusted to a 3-degree inclination). When the bundle breaks, the arm drops, and the brake stops the sliding weight immediately, permitting a scale reading to be made (*6*). The jaws are then removed from the tester and the two halves of the broken bundle (*2*, right) are removed with a pair of tweezers (*3*, right) and placed on the arm of a torsion balance (not shown) for weighing. The scale reading is then divided by the bundle weight to give the Pressley Index.

Materials Tested

In order that the data represent as homogeneous populations as it was feasible to obtain, all tests were made on either:

1. A thoroughly blended sample of U.S.D.A. 1941 check test sample No. 1-115, obtained through the courtesy of the Cotton Ginning and Fiber Testing Laboratories, U.S.D.A., Stoneville, Mississippi.

The data supplied by the U.S.D.A. indicated an average Pressley Index of 7.52 for the sample. No other statistics were given. Three different sets of data on this cotton accumulated during this study gave the following results:

(*a*) 36 breaks:	Average	—7.56
	S. D.	—0.29
	S. E.	—0.049
(*b*) 20 breaks:	Average	—7.60
	S. D.	—0.44
	S. E.	—0.101
(*c*) 20 breaks:	Average	—7.56
	S D.	—0.38
	S. E.	—0.087

2. An accumulation of fibers representing the $^{19}/_{16}$-inch, $^{15}/_{16}$-inch, and $^{11}/_{16}$-inch length groups, each segregated from the others, selected from a bale sample of Bobshaw No. 1 cotton by means of a Suter-Webb Sorter.

This bale sample, taken from a Middling White bale supplied by the Bobshaw Chemurgic Plantation, Heathman, Mississippi, weighed 400 grams and was accumulated by taking 8 pinches from each of the 6 sides and 3 pinches from the center of the bale.

Methods

All tests were made under standard conditions of temperature and humidity (65 percent R.H., 70°F).

Two machines and two operators were used exclusively during the study.

Controlled pressures on the jaw screws, as well as estimates of pressures normally reached by the operators, were obtained by means of a Sturtevant Torque Wrench, 0–25 inch-pounds capacity, with a spacial adaptor fitting the wrench to the jaw screws.

All weighings were made on a Roller-Smith Torsion Balance, 0–52-milligram capacity. The accuracy of this balance was found to be quite satisfactory when compared to a standard chainomatic balance.

Tests for significance of differences were made by an analysis of pooled variance and the use of Student's "t" function. For the purpose of this study, a *real or significant difference* was defined as that difference between any two average values which indicated a *minimum* of 95 percent probability that the

two average values differed because of some factor other than a normal sampling variation, as defined by Student's probability curve [2].

Experimental Results; Discussion

In initiating a study of the particular variables noted below, several indeterminate factors were recognized as capable of influencing the data but were not considered as being within the scope of this study. They were:

1. *In the preparation of the bundle, the effectiveness with which short fibers and trash are removed.* The effect of trash is obvious. The influences of short fibers may be several. The efficacy of test depends in part on the fibers extending completely across the jaws, at right angles to the edge of the jaws. Short fibers may float at odd angles in a bundle and may extend but a fraction of the distance across the jaws. Beyond exercising care in combing the bundles during their preparation, no further attempt was made to evaluate the influence of this variable.

2. *In building the tester, the efficiency with which the distance between the contact faces of the two jaws approaches zero.* Small deviation from zero would probably bring about a distortion of the fibers between the jaws, causing shearing effects of indeterminate magnitude. Moreover, if there is to be any space between the two jaws, it would seem that a fairly wide spacing permitting an adjustment of fibers to the stress through slippage with a concomitant reduction of apparent strength losses due to progressive failure would be desirable. Again, no attempt was made to do more than recognize the existence of this variable and let this recognition enter qualitatively into attempts to set a limit of accuracy on the tester.

3. *In making the test, the effectiveness with which fiber slippage in the bundle can be reduced to a minimum and the crushing and shearing of fibers avoided.* The steel face of each jaw, which is tightened against the leather on which the fibers are laid, is grooved, and the fiber bundle bends over the edges of this groove. By the time sufficient pressure has been exerted to eliminate fiber slippage (at least gross slippage), it is conceivable that a considerable shearing force has been set up against the fibers, particularly those fibers immediately adjacent to the steel jaw face. No attempt was made to express this effect quantitatively except as the study of the effect of jaw-screw pressure might be interpreted in this light.

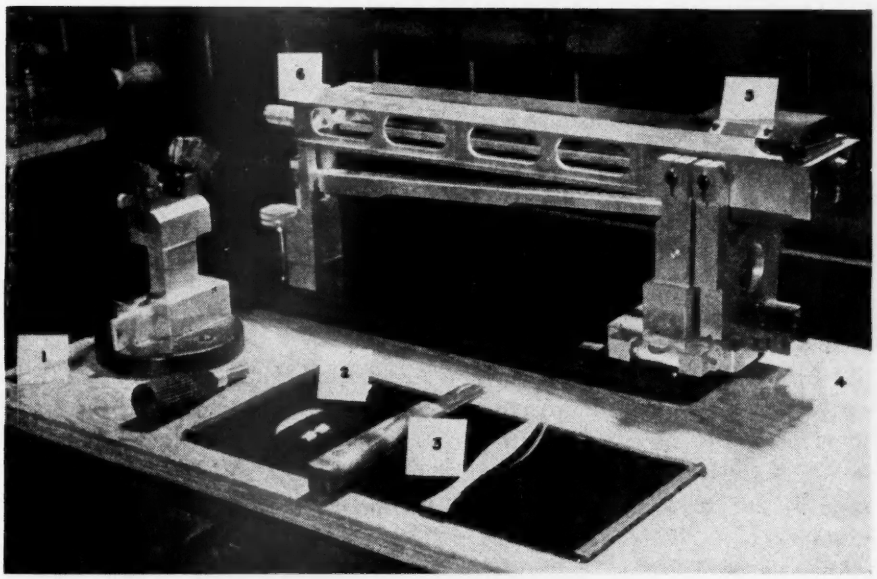

FIG. 1. *Photograph of a standard model of the Pressley Tester.*

Part I. Variations Due to Machine, Operator, and Sampling Factors

Keeping these indeterminate effects in mind, the following factors were studied:

1. *Effect of Two Different Machines on the Pressley Index.* Utilizing the fibers from the three length groups selected from the Bobshaw No. 1 bale sample, each operator made 30 breaks in each length group on each machine.

The results of these tests are summarized in Table I. Analysis of the data indicated that operator B could show a real difference between the two machines in all three cases, but operator A could show a real difference only once in three times. However, when the data of both operators were pooled for each machine, a real difference was evi-

TABLE I. EFFECT OF MACHINE DIFFERENCE ON PRESSLEY INDEX
(Bobshaw Bale Sample)

Sample length group (in.)	Operator	Machine	No. of breaks	Pressley Index Average	Pressley Index S. D.	Difference between machines	Probability difference is real (%)
1 9/16	A	X	30	8.22	0.33	0.04	39.0
	A	Y	30	8.26	0.24		
	B	X	30	8.14	0.43	0.35	99.8
	B	Y	30	7.79	0.32		
	A + B	X	60	8.18	0.38	0.15	98.0
	A + B	Y	60	8.03	0.37		
1 5/16	A	X	30	7.86	0.45	0.34	99.2
	A	Y	30	7.51	0.48		
	B	X	30	7.95	0.29	0.46	99.9
	B	Y	30	7.49	0.26		
	A + B	X	60	7.91	0.38	0.41	99.9
	A + B	Y	60	7.50	0.39		
1 1/16	A	X	30	7.49	0.52	0.19	83.5
	A	Y	30	7.30	0.41		
	B	X	30	7.71	0.27	0.34	99.9
	B	Y	30	7.37	0.26		
	A + B	X	60	7.59	0.43	0.25	99.8
	A + B	Y	60	7.34	0.34		

dent each of the three times. The extent of these three differences was 0.15, 0.41, and 0.25, averaging 0.27 ± 0.08 Index.

No reason for this difference between the two testers was apparent. Nor was there any good reason to believe that the results might not reverse themselves at a later date, since the development of worn jaw screws, leather fatigue, etc., and the concomitant effects of developments noted later in this report are continuous and affect any tester in use.

The point to be made, however, is that the chances for increased accuracy of test data are much greater if more than one machine is used in testing a given sample, or if several testers are utilized in standardizing a check test cotton, which may then be used to gage the influence of wear and tear on any one machine.

2. *Effect of Operator Difference on Pressley Index Values.* Table II summarizes the tests run for the purpose of isolating the effects of operator differences. Actually, these are the same data shown in Table I, but regrouped to illustrate the point in question.

Analysis of Table II indicated that two out of three times there was no real difference between operators, but when the data for both machines were pooled for each operator, the accuracy was increased to the extent that two out of three times a real difference existed between operators. The average value of these differences between operators was 0.15 ± 0.07 Index.

The nature of these data were such as to lead to the question: Were the operators truly eccentric in their testing techniques, or could the results be due to exceedingly unusual sample variations despite the apparent care that had been exercised in preparing the sample and its universe?

To study this point further, the data obtained for use in Tables I and II were analyzed for some of the effects of the number of breaks made.

3. *Effect of the Number of Bundles Broken on the Pressley Index Value.* In Table III, there are summarized the statistics of all breaks made within each length group isolated from the bale of Bobshaw No. 1.

To make the most effective use of these data, it was necessary at this point to arbitrarily select some limits between which it seemed desirable to have any

TABLE II. EFFECT OF OPERATOR DIFFERENCE ON PRESSLEY INDEX
(Bobshaw Bale Sample)

Sample length group (in.)	Operator	Machine	No. of breaks	Pressley Index Average	Pressley Index S. D.	Difference between operators	Probability difference is real (%)
19/16	A	X	30	8.22	0.33	0.08	59.0
	B	X	30	8.14	0.43		
	A	Y	30	8.26	0.24	0.47	99.9
	B	Y	30	7.79	0.32		
	A	X + Y	60	8.24	0.29	0.27	99.9
	B	X + Y	60	7.97	0.42		
15/16	A	X	30	7.86	0.45	0.09	64.0
	B	X	30	7.95	0.29		
	A	Y	30	7.51	0.48	0.02	18.0
	B	Y	30	7.49	0.26		
	A	X + Y	60	7.69	0.49	0.03	35.0
	B	X + Y	60	7.72	0.36		
11/16	A	X	30	7.49	0.52	0.22	95.0
	B	X	30	7.71	0.27		
	A	Y	30	7.30	0.41	0.07	56.0
	B	Y	30	7.37	0.26		
	A	X + Y	60	7.40	0.47	0.14	95.0
	B	X + Y	60	7.54	0.31		

Pressley test data confined with any degree of accuracy desired. For the sake of the argument (and based upon no other consideration), the limits which were defined for this study were: *plus or minus 0.25 of an index*.

Utilizing the formula:

$$\text{S. E.} = \frac{\text{S. D.}}{\sqrt{n-1}},$$

where S. D. = standard deviation
and S. E. = standard error,

assuming a S. D. of 0.38 (S. D. for the 19/16-inch group (Table III)) and as a preliminary estimate not correcting the odds for small sample variations, it may be shown from the data listed in Table III that:

1. To reproduce the average of 8.10 (19/16-inch group) within the limits of ± 0.25, 2 out of 3 times (67 percent accuracy), the S. E. must equal 0.25 and the number of breaks necessary in such a population should be $n = 4$.

2. To reproduce the average of 8.10 ± 0.25, 16 out of 17 times (94 percent accuracy), the S. E. must equal 0.125 and the number of breaks should be $n = 11$.

3. To reproduce the average of 8.10 ± 0.25, 134 out of 135 times (99 percent accuracy), the S. E. must be 0.083 and the number of breaks should be $n = 22$.

Similar calculations within the 15/16-inch and the 11/16-inch groups yield similar results.

It would thus appear that the practices generally followed in the various laboratories using the Pressley Tester are capable of discriminating between differences of about 0.5 of an index, and that the ability to reproduce results closer than this becomes markedly more difficult if fewer than 10 breaks are made.

TABLE III

Length group (in.)	No. of breaks[1]	Average	S. D.	S. E.
19/16	120	8.10	0.38	0.035
15/16	120	7.70	0.43	0.039
11/16	120	7.47	0.41	0.037

[1] 30 breaks by each of 2 operators on each of 2 testers.

TABLE IV. EFFECT OF SAMPLE SIZE ON RELIABILITY WITHIN LIMITS OF AVERAGE ±0.25 PRESSLEY INDEX (Bobshaw, $\frac{19}{16}$-Inch Length Group)

Sample size (n)	No. of samples (N)	Calculated S. E.[1]	t	Probable % of samples within limits	
				Calculated	Observed
30	4	0.071	3.5	99.7	75
20	6	0.087	2.9	99.0	83
10	12	0.127	1.97	92.0	75
6	20	0.170	1.47	85.5	75
3	40	0.269	0.93	65.0	60

[1] Calculated S. E. $= \frac{\text{S. D.}}{\sqrt{n-1}}$

Total of 120 observations, average P. E. = 8.10, S. D. = 0.83, S. E. = 0.035.

This statement assumes that the population studied is adequately sampled and that the distribution of strength values follows a normal curve. As a check on the validity of this assumption for cotton in general and the populations studied in particular, the data used in preparing Table III were further regrouped by $n = 3$, 6, 10, 20, and 30 breaks, at random, as shown in Table IV, including only the data covering the $\frac{19}{16}$-inch length group. The percent of each group actually falling within the prescribed limits was taken as the "Observed Probable Percent of Samples Within Limits." The calculated values were obtained from Student's probability curves given by Ezekiel [2].

Analysis of the data shown in Table IV revealed that they did not fall exactly within the limits that were predicted from the theory of normal sample variation. In the case of 10-break averages, the accuracy was only 75 percent rather than 92 percent; in the cases of 20- and 30-break averages, the accuracy was roughly 83 and 75 percent, respectively, rather than close to 99 percent. The 3- and 6-break averages more closely approximated the predicted accuracy.

Thus, even though only a few samples of the larger groups were available, their departure from theory was somewhat greater than that normally allowed. An explanation was to be sought, then, in the character of the material being tested.

The production and handling of cotton is of such a nature as to make it a logical assumption that fibers of the same characteristics could be concentrated in small groups of widely different values throughout the population being sampled. Tentatively, this phenomenon has been labeled a "concentration effect." It has been our repeated experience, whether testing for Pressley Indices, immaturity by the NaOH technique, fineness, or average length by Suter-Webb arrays during various stages of manufacturing, that irrespective of how thoroughly the sample may appear to have been randomized, it has been impossible to eliminate this grouping or "concentration effect." Apparently, small groups of fibers representing some common point of origin seem to persist, at times, in highly localized clusters.

It would therefore seem that, while two operators can be trained to duplicate each other's results with reasonable accuracy, the (1) nature of the methods of preparing baled cotton; (2) inherent variability

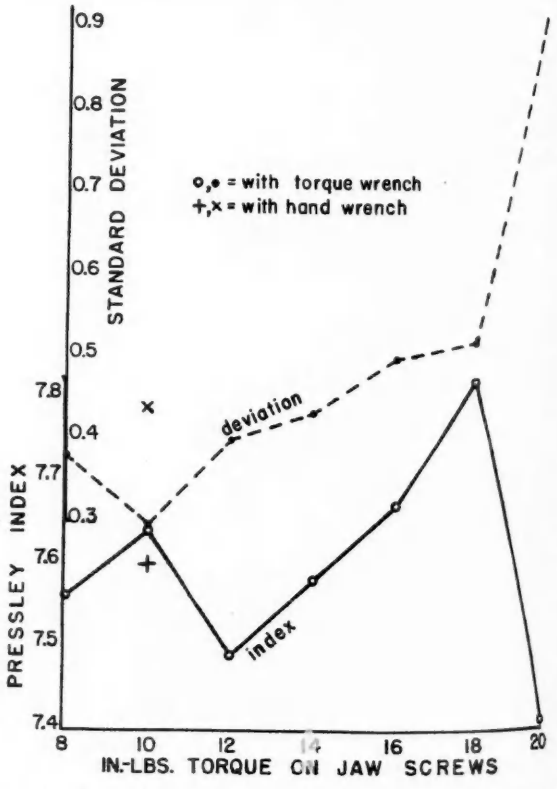

FIG. 2. *Pressley Index and its deviation vs. torque on the jaw screws.*

TABLE V. EFFECT OF BUNDLE WEIGHT ON PRESSLEY INDEX[1]
(Check Test Cotton)

Increasing order of bundle weight	Bundle weight (mg.) Average	S. D.	Range	Pressley Index Average	S. D.	Range
1st 10 breaks	1.788	0.113	1.58–1.92	7.70	0.42	7.14–8.17
2nd 10 breaks	2.020	0.041	1.94–2.06	7.63	0.24	7.32–7.97
3rd 10 breaks	2.106	0.038	2.06–2.16	7.63	0.33	6.95–8.05
4th 10 breaks	2.226	0.035	2.16–2.26	7.52	0.22	7.12–7.90
5th 10 breaks	2.320	0.035	2.26–2.36	7.80	0.22	7.48–8.06
6th 10 breaks	2.458	0.066	2.38–2.60	7.62	0.36	7.18–8.31
Average all 60	2.153	0.225	1.58–2.60	7.65	0.29	6.95–8.31

[1] 2 machines, 2 operators, jaw pressure controlled at 10 in.-lbs. torque. Differences between indices are not significant.

of cotton; (3) the necessary compromise between the desirable practice of making large numbers of breaks and the practical number that can be made if many tests are to be run; and (4) the small bundle size demanded by the machine design, all tend to limit the sensitivity of the Pressley Test and to call for the use of extreme caution in defining significant strength differences between various cottons.

Part II. Variations Due to Mechanical and Manipulative Factors

In order to demonstrate the sensitivity of the test to possible variations in technique, and/or mechanical defects, the effect of several factors was studied, as follows:

1. *Effect of Jaw-Screw Pressure.* Figure 2 graphically illustrates the effect of jaw-screw torque, measured with the Sturtevant torque wrench previously described. Beyond 20 inch-pounds, the jaw screws consistently sheared off. Each point is the average of three tests of 20 breaks each made by each operator on each machine. The cotton was also tested in the usual way with a hand wrench and these values are shown as a torque of 10 inch-pounds, since it was found that the normal range of torque developed by the operators was about 9–12 inch-pounds.

On the whole, it would appear that jaw-screw torque had little effect on the average index obtained, the maximum variation being only a little over 5 percent. If a trend is to be read into these data, it might be said that the higher torques give slightly higher results up to a maximum value. Beyond this, effects are noted which cause a sharp decrease in index values, due possibly to fibers crushing and shearing.

There seemed to be a more positive trend toward increased variability when high jaw screw torques were used.

2. *Effect of Bundle Weight.* In routine operation, no effort is usually directed toward obtaining bundles of exactly constant weight. An experienced operator can tell very quickly, however, approximately the right-sized "pinch" of a particular cotton to get a scale reading within the center portion of the scale.

The calculation of the Pressley Index from the scale reading and bundle weight assumes a linear relation between these two variables that passes through zero—that is, the index is the slope of the linear function and is the same for all values of bundle weight or scale reading. This assumption was checked and found to be correct within the ordinary range of weights encountered by our operators. Correspondence with other laboratories indicates that this range is fairly representative.

A portion of the data used to check the above assumption is given in Table V. Sixty breaks were arranged in increasing order of bundle weight, and averages and standard deviations were calculated for each successive group of 10 breaks. The differences between the average indices shown were not significant.

It may be concluded on the basis of these results that the ability or inability to reproduce Pressley Index averages is little affected by the range of bundle weights normally encountered in routine testing.

3. *Effect of Bundle Width.* As with bundle weight, no effort is made in routine work to control the width of the bundles beyond the qualitative observation that the bundle is the "right" width, based on the operator's experience. During the course of this study, and occasionally during routine testing, enough bundles have been measured to indicate that

TABLE VI. EFFECT OF BUNDLE WIDTH ON PRESSLEY INDEX[1]
(Check Test Cotton)

Test No.	Machine	No. of breaks	1/16 in. Index	1/16 in. S. D.	1/8 in. Index	1/8 in. S. D.	1/4 in. Index	1/4 in. S. D.	3/8 in. Index	3/8 in. S. D.	1/2 in. Index	1/2 in. S. D.
1	X + Y	60	7.62	0.50	7.64	0.37	7.17	0.35	6.78	0.54	6.58	0.48
2	Y	100			7.62	0.37	7.23	0.46			6.34	0.57
2	X	100			7.92	0.49	8.03	0.52			7.43	0.69
3	X + Y	20	7.60[2]	0.44[2]								

[1] 2 operators.
[2] Uncontrolled width, estimated range = 5/32 in.–1/4 in.

the normal width attained by the operators ranged from 5/32 inch to 1/4 inch. As a check against variations in the test data developed by bundle width, breaks were made on bundles of various widths. The results of these tests are shown in Table VI and Figure 3 (the latter reproduces Tests Nos. 1 and 3 from Table VI graphically).

It was evident from these data that the width of the bundle had a marked effect on the Pressley Index. It would seem from Figure 3 that the estimated range of widths commonly used was too broad, or that the two operators used a predominance of the narrower bundles in making the uncontrolled width tests. It should be noted that for routine testing, within the limits of reproducibility previously discussed (10 breaks with a ± 0.25 Index accuracy), the effect of bundle width below 3/16 inch was not significant, while widths of 1/4 inch and over lowered the average index by a significant amount. The 1/8-inch and 1/4-inch bundles gave the least-variable data, as indicated by the standard deviations of Test No. 1 (Table VI).

The magnitude of the effect of this variable (namely, a 13 percent decrease in the index as the bundle width increased from 1/8 inch to 1/2 inch) was almost three times the maximum variation caused by previously discussed jaw-torque or bundle-weight changes. The data are not sufficient to serve as a basis for a proposed standard width, but they do point definitely to the necessity of fixing such a standard. From the data shown in Table VI and Figure 3, it would appear that a standard bundle width of 1/8 inch might be acceptable, but considerably more data obtained in a coordinated program from the various laboratories using the Pressley Tester should be accumulated before a standard is accepted.

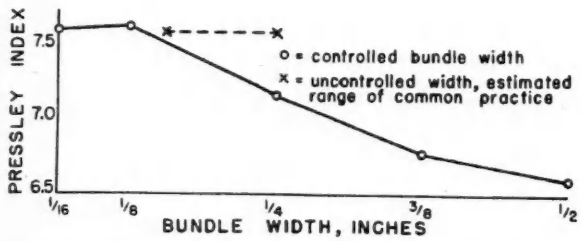

FIG. 3. *Effect of bundle width on Pressley Index.*

The nature of the results obtained in this study of the effects of bundle width suggested that instead of attempting to *remedy* the sensitivity of the Pressley Tester to bundle width by standardizing the width, a *cure* should be attempted by redesigning the breaking jaws and jaw support. Considerable discussion has centered around the design of the Tester and the results of this study emphasize that the greatest need for redesign lies in the method used to hold the bundle and apply the breaking load.

As an interesting sidelight of the effects of bundle width, Test No. 2, Table VI, indicates that the differences between the two machines used in this study were greatly magnified as bundle width increased, to the point that at a 1/2-inch bundle width the two machines differed by 1.09 indices.

4. *Effect of Bundle Angle.* The effect of varying the angle made by the long axis of the bundle to the sides of the breaking jaws is shown in Figure 4.

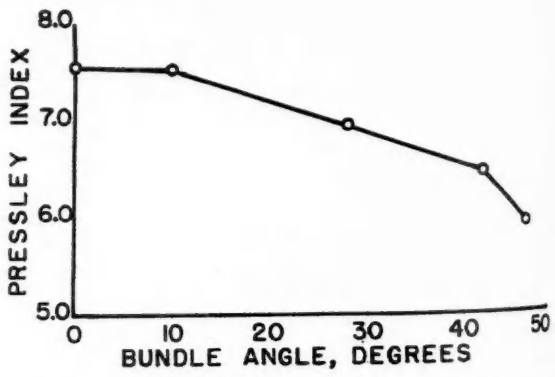

FIG. 4. *Effect of bundle angle on Pressley Index.*

TABLE VII. EFFECT OF TIME OF DAY ON PRESSLEY INDEX VALUES OBTAINED DURING NORMAL OPERATIONS (Check Test Cotton)

Date	Operator	Pressley Index average[1] Morning	Noon	Evening
6/15/44	A	7.55	7.38	7.47
	B	7.44	7.51	7.36
6/16/44	A	7.68	7.42	7.81
	B	7.82	7.65	7.43
6/17/44	A	7.50	7.30	—
	B	7.38	7.43	—
6/19/44	A	7.80	7.24	7.37
	B	7.37	7.38	7.33
6/20/44	A	7.31	7.05	7.19
	B	7.52	7.57	8.03

[1] Average of 10 breaks by each operator on one machine.

Since this variable lends itself to even closer qualitative control than either bundle weight or bundle width, it may be concluded that any slight variations in bundle angle normally encountered should have little effect upon the index values obtained.

5. *Effect of the Time of Day.* Some comment and no little mysticism have been noted in the literature on the Pressley Tester concerning the lower values obtained in the afternoon than in the morning [1, 3]. To check the magnitude of the effect and to determine the reason for its existence, three tests were made, using the check test cotton, wherein:

1. During the normal routine of testing, the first test in the morning, the first test made immediately after lunch, and the last test of the day made by each operator were isolated. These test data are shown in Table VII.

2. Each night, one set of jaws was clamped shut at normal testing pressure on a bundle of fibers and left overnight. During each day, these jaws were used in routine testing and data isolated as in paragraph 1 above. These data are shown in Table VIII.

TABLE VIII. EFFECT OF TIME OF DAY ON PRESSLEY INDEX VALUES OBTAINED WHEN JAWS ARE KEPT UNDER PRESSURE OVERNIGHT (Check Test Cotton)

Date	Operator	Pressley Index average[1] Morning	Noon	Evening
6/29/44	A	8.25	7.89	7.54
	B	7.75	7.66	7.33
6/30/44	A	8.21	7.84	7.78
	B	7.73	7.32	7.63

[1] Average of 10 breaks by each operator on one machine.

TABLE IX. EFFECT OF TIME OF DAY ON PRESSLEY INDEX VALUES OBTAINED BY USING ONE SET OF JAWS FOR ONLY THREE TESTS DURING THE DAY (Check Test Cotton)

Date	Operator	Pressley Index average[1] Morning	Noon	Evening
6/21/44	A	7.10	7.67	7.40
	B	7.43	7.61	7.47
6/22/44	A	7.80	7.44	7.70
	B	7.62	7.79	7.80
6/23/44	A	7.63	7.74	7.64
	B	7.71	7.41	7.27

[1] Average of 10 breaks by each operator on one machine.

3. One set of jaws was removed from routine testing and only three tests were made each day using these jaws, one in the early morning, one in the early afternoon, and one late in the afternoon. These data are shown in Table IX.

The data shown in Tables VII, VIII, and IX do not conclusively demonstrate the previously reported tendency for operators to obtain lower values in the afternoon of a day of routine testing. However, if a trend in this direction is to be read into the data, it may be noted that a possible cause of the phenomenon is some type of jaw fatigue probably centering in a

TABLE X. EFFECT OF ONE WORN JAW SCREW IN MACHINE X ON PRESSLEY INDEX VALUES[1]

Length group (in.)	Operator	Machine	Pressley Index	Difference
$\frac{13}{16}$	A	X	7.05 ± 0.061	1.49
		Y	8.54 ± 0.078	
	B	X	7.85 ± 0.059	0.87
		Y	8.72 ± 0.076	
$\frac{15}{16}$	A	X	6.58 ± 0.064	1.56
		Y	8.14 ± 0.095	
	B	X	7.40 ± 0.045	0.16
		Y	7.56 ± 0.076	
$\frac{13}{16}$	A	X	6.64 ± 0.115	1.02
		Y	7.66 ± 0.074	
	B	X	7.26 ± 0.061	0.48
		Y	7.74 ± 0.066	

[1] Each index is average of 30 breaks.

gradual change in the resilience of the leather grips. Table IX indicates that if the jaws were used infrequently during the day the questionable tendency of the data in Tables VII and VIII toward lower evening values disappeared. This suggests that if machines are in constant use in a laboratory a midday change of jaws might eliminate some degree of variability in the data.

6. *Effect of Worn Jaw Screws.* Quite accidentally, a considerable quantity of data was accumulated relating to the length groups of the Bobshaw cotton in which a marked discrepancy between the two machines used was observed and traced to the presence of one worn jaw screw on one machine. The worn condition of this screw caused both operators to bear down with exceptional pressures, which resulted in a marked lack of balance between the two jaws. Table X lists the data reflecting this mechanical defect.

It may be noted that one operator showed a difference between the two machines of 1.56 Index, and that the results of the two operators differed more widely than usual with one another.

The significance of these data is based mainly on the fact that they emphasize the need for a rigid check on the mechanical condition of the tester if it is to yield the most useful and accurate data.*

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* Acknowledgment is due to Mr. Jack D. Towery for supervision of the testing laboratory and for helpful suggestions in the course of obtaining the laboratory data.

WE know of one enterprising business man, the head of a successful, growing company, who was asked, "How do you happen to stumble on all these new products?" Pointing to the Research Building across the way, he replied, "Well, you see we maintain a 'Stumbling Department' especially for that purpose."—*The Research Viewpoint*

WOVEN into the design of a tapestry which hangs in our office is a legend reading, "Our destiny is not to create but unveil." This is another way of saying the same thing: that the great discoveries of tomorrow and the day after were "there all the time," waiting to be unveiled by the scientist.—*Gustavus J. Esselen*

Problems for Future Quartermaster Textile Research

Lieutenant Colonel Stephen J. Kennedy, QMC*

Many facts, hitherto unpublished, with respect to the textile research program initiated in 1942 by the Research and Development Branch of the Office of The Quartermaster General are highlighted in this paper by Lt. Colonel Stephen J. Kennedy. Problems which have pressed for solution, the manner in which these problems were attacked, and the noteworthy accomplishments are briefly outlined. Nine areas of research which must occupy the attention of industry as well as of the military services are described.

This paper deserves the careful attention of all textile men. It was read by Colonel Kennedy, Chairman of the Conference on Quartermaster Research held at the National Academy of Sciences, in Washington, D. C., October 25, 1945. Other papers given at the conference were: "Importance of Quartermaster Research in Winning the War," by Lieutenant General Edmund B. Gregory; "Washable Woolens for the Army," by Captain Henry F. Clapham; "The Use of Army Service Testing Techniques in the Development and Interpretation of Laboratory Textile Tests," by Oliver P. Beckwith; "Tropical Deterioration of Textile Products," by Dr. William H. Weston; "Synthetic Fabrics in the Quartermaster War Program," by Chandler Robbins, II; "Increasing the Wear Life of Army Textiles Through Research," by Captain Stanley Backer; and "The Program of the Quartermaster Corps for Future Research," by Brigadier General Georges F. Doriot; and "Comments on the Program of Research," by Dr. Harold DeWitt Smith.

The above papers are included in a complete report, with illustrations, which is being published under the sponsorship of the Intersociety Council for Textile Research. Copies may be had at $1.00 each by writing Textile Research Institute, Inc., 10 East 40th Street, New York 16, New York.

AT the start of the research program initiated after the formation in 1942 of the Research and Development Branch of the Office of The Quartermaster General, the problems in the field of textiles which demanded immediate solution were basically physiological. It was necessary to find out a great many things about clothing, which comprises the largest use of Quartermaster textiles, that had never seriously concerned our industry in the past. We had to know what types of clothing were best for men who had to live and fight out of doors for days on end in the Arctic, in desolate mountain areas, in deserts, or in the steaming jungles; how we should design them; and what would constitute minimum protection for fighting efficiency.

The textile and clothing industries did not have the answers to these questions. The people who have to live or work out of doors under extreme climatic conditions comprise an important textile consumer group; but except for recent fabric developments for winter sports clothing, little interest had been shown on the part of the textile industry in research in this field.

The research program which this Branch undertook embraced a broad field that never before had been subjected on an integrated basis to thorough, controlled laboratory and field tests. It would take all the time alloted to this entire meeting to begin to do justice to the scientific work in the study of military clothing which has been carried on during the war. We should have to include the physiological and climatic studies undertaken in our Climatic Research Laboratory at Lawrence, Massachusetts, the work done at the Harvard Fatigue Laboratory, at

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the University of Indiana under Dr. Sid Robinson, and other private and university laboratories, as well as extended field tests in all climates and terrain.

From these extensive studies, the scientists learned for the first time how to clothe men properly for living and fighting effectively under extreme climatic conditions. Much of what we now know has been learned while testing new combat clothing. As a result, the combat uniforms of the American Army today are the product not only of testing by Army Service Boards, as well as extended field tests, but also of an unparalleled amount of scientific research.

A great deal of what the physiologists have told us about military clothing is concerned with clothing design, a subject which traditionally has been of very little interest to the textile industry. This is indeed most unfortunate, since textiles and clothing are actually two aspects of the same problem; no significant research in textiles can long be divorced from research in clothing. Frequently a greater improvement has been made by changing the design and fit of clothing than by improving the functional performance of fabrics. From this study of military clothing we have obtained for the first time an adequate statement of the required characteristics for military textile fabrics.

Our research in textiles—that is, in fibers, fabrics, and finishes—has been characterized first by what may be considered applied research or development. Existing items have been subjected to continuous improvement either by raising the level of specification performance, by adopting an improved fabric construction, or by using a new finishing treatment.

It has not been possible, however, to find satisfactory solutions for all of our problems in this way. Those of us who have guided the research and development program of the Quartermaster Corps have been increasingly concerned, as the war has progressed, with fundamental research problems in the field of textiles. We are to discuss here today nine such areas of research which must have the attention not only of the military services but of the industry itself if further improvements are to be made in military textiles, and, for that matter, in civilian textiles. Five of these will be discussed in more detail by subsequent speakers, all of whom have actually been working on these problems for the Quartermaster Corps and who have backgrounds in their respective fields which are probably unequaled elsewhere in the textile industry.

The first fundamental research problem which I wish to present is concerned with the improvement of water-resistant fabrics.

1. Improvement of Fabrics with Respect to Water-Resistance

As far back as one cares to go, armies have fought in wool clothing. Perhaps this was due to the universality of wool, to the fact that among almost all peoples of the world wool furnishes the basal material for clothing. But wool also has the advantage that, because of its resilience, it is a good insulator and therefore people can keep warm in wool garments.

The drawbacks to the use of wool in the outer garments of soldiers have never seemed to weigh heavily upon the minds of tradition-bound military or textile men. The fact that because of their nature and construction wool fabrics are not resistant to biting wind and that wool has the property of absorbing large amounts of water have been overlooked.

These factors, however, have counted heavily in all of the physiological studies which we have made of military clothing, particularly in winter or cold-climate clothing in which wool has traditionally been used. Penetration of wind through the clothes chills the skin and lowers the body temperature. Wet clothing is also a hazard, since water is a good conductor of heat as contrasted with still air, which permeates the resilient structure of wool fabrics and makes them such good insulators when dry. To evaporate the moisture in wet clothes, body energy must be expended. When a man is at rest, lying in a foxhole or sleeping, he may not generate enough body heat to do this, with the result that there is a lowering of body temperature, loss of efficiency, and danger to health.

The abandonment of wool in outer garmets of Army combat clothing has been one of the most important changes in military textiles during the war. The fact that an Army overcoat itself weighs 7 pounds and can absorb in a moderatively heavy rain an additional 9 pounds of water was one factor contributing to this change. Most important, however, was the fact that lighter weight cotton textiles showed themselves to be far superior in wind- and water-resistance in all controlled laboratory and field tests, as well as in actual combat. By making this substitution, wool could then be relegated to its real task of providing insulation in under layers of clothing beneath the outer cotton water-resistant garments.

There it could be kept from getting wet from the outside while body moisture could be transpired through the outer fabric.

Furthermore, these cotton water-resistant fabrics have other desirable functional characteristics not possessed by wool. They are stronger, more resistant to tearing, they dry more quickly, and after they have been used in the grime of battle they can easily be washed even under the most primitive laundering conditions. Their water-vapor permeability permits adequate transpiration of body moisture to the outer air even in the most densely constructed fabrics of this type.

At the start of the war the development of water-resistant fabrics was concentrated upon improved water-repellent treatments. This arose in part from the continual development of new and better products by the chemical industries, and in part because the importance of fabric construction in keeping the soldier dry had not been fully appreciated.

Fabrics of the wind-resistant, water-repellent type stem from the initial development of Grenfell cloth, and English fabric developed for use in Artic exploration, and its American counterpart, Byrd cloth, which was used by the Byrd South Pole Expedition. They are fine twills made with 80/2 combed warp and filling. Since the amount of these fabrics that could be produced by American industry was limited, alternates had to be developed if the Army as a whole was to be equipped. The fabric initially selected for this purpose, after tests of fabrics of many alternate constructions, was a wind-resistant poplin, slightly heavier in weight but with comparable water-resistant properties. Subsequently, when a tougher, more tear-resistant fabric was deemed necessary, a 9-ounce wind-resistant sateen was adopted.

During 1943, samples of English fabrics having better water-resistant properties than any heretofore known in this country were received in our office through military channels. Initial attempts to duplicate the fabrics in this country were unsuccessful and further detailed information was accordingly obtained from England.

The basic principle of construction of these fabrics was worked out by Dr. F. T. Peirce, formerly of the Shirley Institute and now director of research in the North Carolina State College School of Textiles. A very dense fabric with a high warp cover was constructed, using an oxford weave to permit laying in a very large number of warp ends. The swelling properties of the cotton when wet then closed up the fabric and reduced the penetration by water.

Several fabrics employing this principle of construction were adopted by our office and have been procured in large quantities for use in winter combat clothing and related items. Recently the 9-ounce wind-resistant oxford has been adopted as the standard fabric for winter combat clothing in place of the 9-ounce sateen.

Type of Research Required

We do not consider, however, that these fabrics represent the ultimate in water-resistant fabric development. It is evident that a great deal more needs to be learned about the construction of this type of fabric and we are not sure that the principles of construction and finishing which we are presently employing will produce the fabric that is required. In the first place, the effects of the swelling of cotton fibers upon the performance of water-resistant fabrics are certainly not adequately understood. A broad study in this field has been initiated by the Southern Regional Laboratory of the U. S. Department of Agriculture upon the request of our office, to extend studies previously made and to include the following lines of research:

1. Development of precision techniques for the direct measurement of swelling, including changes in length as well as in section dimensions. Application of tension to fibers during the study of swelling properties.
2. Measurement of rate and extent of swelling, and determination of effect of such factors as pH, cyclic wetting and drying, fiber structure, non-cellulosic content, finishing, and water-repellent treatments.
3. Measurement of forces involved in fiber swelling.
4. Study of surface physics and chemistry of fibers.
5. Correlation of precision measurements with more readily measured properties, possibly on yarns or fabrics.

Because of its unique responsibility for fundamental research in the field of natural fibers, it is appropriate that this work should be undertaken by the Department of Agriculture.

In addition to the above basic study of this important physical characteristic of cotton fibers, a research project is now under way at the Institute of Textile Technology to develop unequivocally the principles of design of water-resistant fabrics. Four

series of fabrics are now being prepared for careful evaluation of the effect of variations in fabric constructions, holding cover factors constant in one case, tightness constant in another, and constant warp-cover-factor and constant weft-tightness in another. Certain variations in weave are being included in a further series.

It is also planned to evaluate the efficiency of water-repellent agents at various stages in textile processing, from the untwisted fiber through the woven fabric. This will include the study of the rate of degradation of water-repellency in an effort to understand this phenomenon as it occurs in cotton fabrics. A fourth phase of this study will involve the determination of the principles influencing transmission of liquids through fabric structures.

Beyond this fundamental study of physical properties of fibers as used in water-resistant fabrics, further research is needed for the development of improved water-repellent agents. Our water-repellent finishes today are far better than were those obtainable at the start of the war. Much better ones, we believe, can be developed. The Germans have a whole new range of hydrophobic materials for textiles in a new group of organic compounds derived from ethylene urea. We, in this country, have the promise of important developments in the field of silicones, a unique group of hydrophobic materials, which, when we learn to apply them successfully, may be an ideal type of material to apply to water-resistant fabrics.

Development of water-repellent chemical agents has been regarded by our office as basically the responsibility of chemical manufacturers, who, in their desire to develop improved chemical agents on a competitive basis, have carried on intensive research in recent years, both before and during the war. If such research continues to be productive in meeting our severe requirements of field use and laundering, our fundamental research can be centered upon physical studies of the properties of fibers, yarns, and fabrics and the evaluation of such new water-repellent agents as industrial research produces.

Possibly the solution to this problem of water-resistant fabrics will have to come ultimately from outside the textile industry. There is at least a possibility that manufacturers of plastics may find a material which has all of the important properties of conventional woven textiles and some other desirable properties besides. Some plastic films already developed have the necessary impermeability to water and give promise of having satisfactory water-vapor permeability. These films are amazingly tough and even today are cheaper than cloth. The plastics industry, which is admittedly still in its infancy, has a tremendous research program and, under the impetus it has received during the war, in years to come can be expected to make definite progress in lines parallel to textiles.

2. Improvement of Military Webbing

Webbing used for the personal equipage of the soldier has this in common with the outer clothing of the soldier that has just been discussed: in a drenching rain it will absorb an excessive amount of water, adding as much as 5 pounds to the load on a soldier's back. In any climate, but particularly in the hot, humid types, every ounce of added weight demands a toll from the soldier even when he is only moderately active. The extra load which water absorbed in his webbing equipment forces upon him means that he can carry just that much less payload or else be subjected to a proportionate reduction in his efficiency. The average soldier's solution to this problem is to throw his equipment away when it feels too heavy, despite the importance which it may hold for his efficiency and safety.

Already it has become clear that conventional types of water-repellents do not provide a satisfactory solution to this problem. They result in a permanent add-on of weight which the man must carry all of the time. Furthermore, a considerable part of the added water is held mechanically in the coarse fabric rather than in the fibers or yarns, and is not affected by water-repellent treatments.

To study this problem of reducing the weight of a soldier's webbing equipment, a research project has been set up under the National Academy of Sciences at the Rhode Island State College. A complete restudy of webbing construction and materials, as well as means of reducing water-absorption, is being made.

It has already become clear from a preliminary study of the use of webbing for Quartermaster items that many of the principal uses have distinct functional requirements of their own. In some uses, high resilience is important; in others, resistance to abrasion, and in still others, strength, stiffness, flexibility, or low elongation are needed. The twelve distinct uses include handles, shoulder straps, binders, reinforcing, and adjusting straps.

While redesign and reconstruction of cotton web-

bing may provide a partial answer to the over-all problem, it is apparent that there are excellent opportunities in this field for the use of some of the synthetic fibers. Such fibers as nylon and saran (vinylidene chloride), for example, are inherently non-water-absorbent and there are new types of fibers now under investigation which have similar properties. Since in webbing there are the three variables—the warp yarn, the stuffer yarn, and the filling yarn—manipulation is possible in all three to obtain the desired properties in the end-product. It is quite possible that the ideal webbing for many military uses will be found to be a three-fiber webbing made of the proper fibers in the proper yarn size, twist, and plies for each of these three component yarns in the webbing.

Other approaches to the problem are coating or laminating of cloth with plastic or rubber compounds and then cutting to size. Procurement was being made of webbing of this type in substantial volume at the end of the war. New advances in coating of glass cloth also hold considerable promise of adapting this fiber to use in webbing.

With this, as with water-resistant fabrics, there is a possibility of finding the ideal solution entirely outside of the textile industry. With the further improvements in strength and notch resistance of plastic films of the type already sold commercially in suspenders and garters, materials of this type may ultimately replace textile webbings in military uses.

3. Improvement of Equipment for Sleeping in the Field

Sleeping gear presents one of the most interesting research problems in the whole textile field because of what appears to be a basic contradiction in military requirements. We must, on the one hand, have bulk in which dead air can be trapped to give the required insulation, while, on the other hand, bulk must be reduced to a minimum in order that a man can carry his sleeping gear on his back. This contradiction in requirements can be resolved in the statement that a satisfactory sleeping-bag filling material should roll up to a minimum bulk on a man's back, but have high bulking value when unrolled. In addition, it must be launderable, durable under repeated load, have high resilience, low thermal conductivity, and minimum weight, and retain its bulking value after laundering.

Of the more than forty different filling materials for sleeping bags which have been tested by our office in our search for a material available in large volume, none has been found which has the properties equal to those of water-fowl down and feathers.

Early in the war when we were concerned with the problem of protecting men in extreme cold, when the Alcan Highway was being driven through to Alaska and there was an urgent requirement for equipment which would enable men to fight under Arctic conditions, we had to provide sleeping gear which would enable a man to get a night's sleep in such extremely cold temperatures as 40 degrees and 60 degrees below zero. We also had to provide sleeping gear for troops who would be fighting in mountainous areas where, even if temperatures may not have been so cold, every unnecessary ounce had to be eliminated from the man's back because of his greater dependence upon man-packing as the basic means of supply. For the rather limited quantities of sleeping gear required for troops such as these, it was possible to provide sleeping bags filled with water-fowl down and feathers in the 40/60 proportion which was adopted early in the war as giving the most efficient use of the down.

However, when it came to providing adequate sleeping gear for the large number of soldiers who perhaps would not have to sleep in below-zero temperatures for any length of time but who normally would be in winter temperatures from a little above freezing down to zero, the problem was a great deal more difficult. Our wool sleeping bags represented a more efficient use of the weight and bulk of wool blanketing materials than the blankets themselves—in fact, controlled test reports indicated that we obtained practically the efficiency of two blankets in one wool sleeping bag made from the blanketing material. But even two wool sleeping bags did not provide the necessary insulation for six hours of sleep at below-freezing temperatures even when dry.

Since it is improbable that in any future emergency the duck population of this country will be sufficiently larger than it was during the war to provide larger supplies of water-fowl down and feathers for this use, it is most desirable that some more satisfactory insulating material be found.

From our research it appears highly improbable that it can be found in any of the natural fibers or filling materials. There is reason to believe, however, that developments in the field of synthetic fibers will ultimately produce a satisfactory fiber for this purpose. As a matter of act, the most promising

material presently being tested is fiber-glass. Possibly some means may also be found for making a durable inflatable sleeping bag of very light weight which can readily be inflated to give the insulation required.

As with winter combat clothing, the problem of water in sleeping bags is particularly acute. The possibility of using waterproof coated fabrics in an outer case has been carefully explored, but although the coating may protect against water from the ground, it creates the other hazard of water accumulation in the bag, resulting in increased weight and ultimately in a great reduction in insulating value. For an outer case on sleeping bags we have again used water-vapor-permeable, water-resistant fabrics which, as already pointed out, need further improvement. As long as soldiers in combat must sleep in the open, the Army will need to continue its research to develop sleeping gear which will be light and of minimum bulk and yet will enable soldiers to keep warm and obtain the rest they must have if they are to fight efficiently.

4. Improvement of Shelter in the Field

In tents there is the problem of water again, this time combined with two other serious problems—the decomposition of cellulose by the action of the rays of the sun and by attack from micro-organisms. There is the further critical hazard of fire in personnel and hospital tents started by incendiary attacks from the air, in which a few seconds of time may make the difference between life and death.

We have learned a lot about tents during the war, in part because not very much was really known about them before the war, and in part because of the severity of the conditions to which tents have been exposed in the tropics, where degrading influences are the greatest. A great deal has been learned about how to finish tentage fabrics, perhaps the most important fact being that this art is still only in its infancy. Considerable has also been learned about fabrics for tents and about tent construction. It can be said today that we can make tents which are far more durable than any that were produced during the war, and are more resistant to leakage and lighter in weight.

Because the testing of tents and tentage fabrics and finishes is necessarily a long process, requiring extended exposure to the elements, some of our conclusions will have to await completion of tests which are now under way. Perhaps the most important of these is the large-scale exposure test at the Quartermaster Board at Camp Lee. There, more than one hundred tents representing different variations of fabrics, finishes, designs, and constructions have been pitched in an exposed area, where they will remain from one to three years. Panels of the same fabrics have been exposed adjacent to the tents so that determination can be made of the influence of structure form as well as of the atmosphere in the performance of the fabrics used in tents.

A most important aspect of this tent test from the standpoint of the textile industry is the extensive work being undertaken in collaboration with scientists from the astrophysical laboratory of the Smithsonian Institution in the measurement of the amount and character of solar radiation which these tent fabrics will receive. In the past, exposure testing of fabrics was limited simply to the notation of hours of sunlight or of the days of exposure and to relating the data to changes in the fabric properties. This test has been organized so that the influence not only of the amount but of the kind of radiation on the degradation of fabrics will be evaluated.

Tent design and construction are being studied by personnel of the University of Louisville Institute of Industrial Research under a research project sponsored by this office and conducted under the auspices of the National Academy of Sciences. The principles of tent construction in relation to adequate distribution of loads, structural stability, and temperature control are being developed in this work.

Industrial research in the field of tentage will depend to a considerable degree upon the findings from current tests. Analysis of the fabrics now on exposure at Camp Lee should indicate constructive lines of research in textile fiber and finishes as well as indicate how light in weight it will be practicable to make fabric for tents, employing the improved construction which has now been adopted. What is learned about fabric construction from the basic project on water-resistant fabrics can also be applied to tentage fabrics. It appears at present that plied-yarn duck will never again need to be used for Army tents, that lighter-weight single-yarn fabrics, far more available in an emergency, will not only be adequate but also better from the standpoint of water-resistance than the heavy plied-yarn ducks which were standard during the war. From the study of the effects of solar radiation upon exposed tents, it

should be possible to find a way to introduce some material into the finish which will reduce the severity of attack in the same way that fungicides are used to prevent attacks by micro-organisms.

5. Shrink-Resistant Treatment of Wool Items

The work of the Quartermaster Corps aimed at providing washable wool items for the Army will be discussed in detail in another paper. It may be pointed out, however, that the American wool industry was not prepared at the outbreak of the war to deal with the military necessity of washing wool items rather than dry-cleaning them. In this respect, it was far behind the British wool manufacturing industry, which has been able to provide the British Army throughout the war with shrink-resistant wool items. We had been content with talking about a mild washing formula for wool without facing the fundamental necessity of altering the physical properties of wool so that it would withstand washing under field conditions.

From the results obtained to date the research program on the shrink-resistant treatment of wool, which was started by our office with the Textile Foundation under a contract from the National Research Council and which is now being continued by the Milton Harris Associates, it may be stated that had the war lasted another six months we should have been procuring at least a portion of all of our wool items processed with a shrink-resistant treatment and, within a year, such a treatment would have been made a specification requirement for every wool item. The savings to the Army already made on the completed part of the program has been more than enough to pay the cost of any research program on Quartermaster items which has been contemplated at any time during the war.

The value of this research to the wool growers and the wool manufacturing industry of this country will also be widely recognized. Regardless of its important peacetime applications in securing new markets for wool or preserving old markets against competition from other fibers, within the Quartermaster Corps it is regarded as only the first step towards a fundamental restudy of military wool clothing. Further research will involve a complete restudy of fabric construction and garment design to take full advantage of the changes in physical properties of the wool and the fabrics resulting from this treatment.

6. Improvement of Abrasion-Resistance of Textiles

In speaking of the improvement of abrasion-resistance of military textiles, it may be worth while to quote a statement which a certain mill president made to us in regard to this project, to the effect that the textile industry does not want to make fabrics which will wear longer—that it wants to make fabrics which will wear out quickly so that people will have to buy more of them. If that view is widely held in the textile industry—which I doubt very much to be the case—then perhaps a lot of people in our industry would do well to study what research to make better products has meant to other American industries.

Such an attitude is certainly alien to the public's point of view which we, who specify what will be bought with the public's money, must have. We are definitely interested in learning how to make fabrics, and items made from them, wear longer. If we could have improved the wear-resistance of our clothing and textile equipage so that it would have lasted only 10 percent longer, other things being equal, a saving to the American public of more than twenty million dollars per month could have been made last year.

As is pointed out elsewhere in this program, there have been technical problems as well as limitations as to available funds which have stood in the way of extended civilian research on the wearing qualities of textiles. The Army's stake in this field, however, is so great that the necessary program of fundamental research into the nature of abrasion of textile fabrics and of ways to reduce the effect of wear by construction changes or improvements in finishing processes, can be justified many times over.

The implications of this project to Quartermaster operations on textiles is very great indeed. When we understand more fully how wear occurs on fibers, yarns, and fabrics, and what the effects of various types of finishing treatments may be, it should be possible to reconstruct our fabrics fundamentally so as to obtain the maximum wearability consistent with other functional requirements. We in the Quartermaster Corps believe that consumers in the civilian economy will be interested also in the application of the results of these studies to the textiles which they buy.

7. Treatment to Resist Tropical Deterioration

The progress which has been made by the Army in the study of tropical deterioration, particularly by

the Quartermaster Corps in the field of cellulose degradation, will easily rank as a major scientific achievement in the field of biochemistry.

There is no denying that the losses in Army material in early Pacific operations were enormous. Experience with the relatively slow rates and infrequency of attack by micro-organisms in a temperate climate was not adequate preparation for the effects of the humid tropical jungles of New Guinea. From the study of microbiological flora in various parts of the world, we now have at least partial answers to a great many questions such as: "What organisms are responsible for degradation?" "Are the same organisms involved in widely separated tropical areas?" "Do they appear in any particular order as exposure is prolonged?" "Which microbiological flora are actively present at the period of greatest rate of loss of tensile strength?"; as well as questions on the sensitivity of cellulose-destroying bacteria to the cell-toxicant type of fungicides used at the present time.

A brief outline of this work is given in a paper being presented later in this program which may serve as a guide to the application of this research to the field of textiles. The value of this work to military textiles will be immediately apparent. Its significance in civilian textiles will, undoubtedly, come to be recognized as the extent of the losses to consumers, even in this country, from attacks upon textiles by micro-organisms are more fully appreciated.

8. Improvement of Seams in Military Clothing and Equipage

Seams constitute one of the least satisfactory elements in military clothing. Early in the war the problem of inadequate seams on waterproof clothing and raincoats arose at the time when it was necessary to change from rubberized waterpoof materials to materials treated with synthetic resins. The impracticability of joining such materials with sewn seams was clear from the failure of the needle holes to close. As a result it was found to be more satisfactory to join such materials with cement than to use conventional sewn seams. A somewhat similar problem still exists on winter combat clothing and equipage made from water-resistant fabrics such as the high-sley oxfords.

The improvements in fabrics and finishes which have been made as a result of continuing research in those fields and are currently being extended have not been matched by corresponding improvements in seams. Water seepage and wicking of water at seams represent a far lower standard of water resistance than is provided by the rest of the garment. Accordingly, further improvements of fabrics and finishing agents must be paralleled by research to improve seam construction to bring seams to at least a correspondingly high standard of performance.

Furthermore, a large poportion of failures in Army clothing and equipage occur at seams. For example, wool clothing salvage studies made in 1943 showed that stitching failures appeared in 59 percent of the garments studied and were more numerous than any other single type of failure with the exception of frays. On wool trousers, stitching failures appeared in 66 percent of the garments. They were not limited to wool garments, since on shirts of cotton khaki they appeared in 42 percent of the entire samples studied and in 27 percent of trousers of cotton khaki.

Seams in textile clothing and equipment constitute one of the few textile areas where the Quartermaster Corps has accepted commercial practice. The inadequacy of this practice in meeting military requirements has been thoroughly demonstrated. It is probably just as inadequate in civilian articles but it does not appear that either the garment industries or consumers have tried to do anything important about it.

During the war, with continual pressure to turn out enormous quantities of clothing, there seemed little that could be done to improve this situation. However, a long-range study of the basic factors involved is planned as a major post-war research project. Part of this research will be directed toward the use of adhesives in place of sewn seams. The properties of specialized adhesives have improved so much during the last few years that adhesives are now available which have a bond strength from fabric to fabric strong enough to tear the fabric. In some items it may accordingly be possible to eliminate the present unsatisfactory methods of joining fabrics by using thread and sewing machines. The manufacture of canvas paulins with cemented seams has already shown considerable promise, and tents made with cemented seams are now on test.

9. Evaluation of New Materials and Processes for Military Use

Most of you in the textile industry have thought of the Army in the past largely as a testing agency

to evaluate your new products for possible military application. Unquestionably this work of the Quartermaster Corps is important. During the war it was intensified by the same emphasis which the winning of the war has had in the textile industry. On our part, as reports of combat experience and data from extended field tests have been received, functional requirements have become more clearly defined, so that it has been possible to evaluate better the relative merits of different products and development ideas submitted by industry.

Testing and research have shown a number of important new applications for synthetic textiles, as is being pointed out in one of the papers to be presented today. The record will show many similar developments in other lines which have been initiated by industry and brought to the Quartermaster Corps as possible answers to our needs. In some instances, they could be adopted at once; others have had no military application, whereas still others could be used only after extensive modifications had been made. We are glad to acknowledge that a great deal of the progress which we have made in the improvement of Quartermaster textiles has come from research and development in commercial firms.

It may be suggested that a broad approach to Quartermaster textile needs will be desirable in view of the rapidly accelerating pace of technology within the textile field today. Some of our problems can be solved by utilizing existing fibers with greater efficiency; by finding the best possible construction and design of fabrics which can be made from these fibers. Further advances will be made by the treatment of present-day fibers either to obtain fundamental modifications in their molecular structure, or by impregnating them with various types of materials or surface-coating them in any one of a great many ways. Still further advances will be made with the development of more new types of synthetic fibers having the specific physical properties needed to meet a given use.

10. Other Problems for Textile Research

The problems which have been discussed above do not by any means exhaust the field for research on military textiles. No mention has been made of requirements for clothing for troops in the tropics, in jungles, or desert areas where the physiological requirements are totally different from those in temperate and cold climates. Perhaps the soldier would be much better off naked in the jungle, if humid heat were the only problem, but he must also be protected against mosquitoes and other insects, the sharp-cutting vegetation, and the rays of the sun. Here lightness in weight is paramount; everything a men wears and carries costs a tremendous premium in exertion.

During the war, one of the most important research projects which we have undertaken has been the development of clothing for protection against gas warfare. Chemical treatments developed early in the war by Chemical Warfare Service for impregnating clothing appeared to cause inexplainable deterioration of cotton fabrics in storage. There were wide variations in the rates of deterioration, with some mills producing very resistant fabrics, whereas fabrics from other mills were particularly susceptible to such deterioration. A painstaking study of all the detailed processes of finishing in all the textile finishing plants, together with a laboratory investigation by the Textile Foundation under the auspices of NDRC, finally indicated the fabric condition under which this type of deterioration occurred and how it could be minimized. By careful selection of finishing plants and continual control testing of their products it was possible to increase the storage life of impregnated clothing so that there was reasonable assurance that the clothing would have adequate life expectancy when needed for protection against gas attack. While gas warfare was not actually used in this war, we had to be prepared for it. Possibly in a future emergency we will have to be prepared with clothing which will protect the soldier against other new forms of attack.

Another important field of research has been the development of clothing for protection against flash burns, particularly to protect personnel on duty in tanks. A process for obtaining an excellent durable flame-resistant treatment on clothing was developed and was just getting into production at the end of the war. It will undoubtedly have extensive applications in the post-war world.

It would be quite impossible in the brief time we have here today to attempt to cover all of the other fields of textile research in which the Quartermaster Corps has a definite interest. Some of them present special phases of the problems already discussed, whereas others constitute distinct problems of their own. Those already outlined, however, comprise the major fields in which the continuance of extensive fundamental research is considered vital to the ac-

complishment of the mission of the Quartermaster Corps.

Much has been said as to what the textile industry has learned from the war. It is true that it has learned how to make new fabrics and how to control quality beyond anything known before the war. I should like to suggest that from our standpoint there have been two major contributions.

First, in attempting to make the kind of fabrics the Army needs to clothe and shelter men properly in all kinds of climates, we have demonstrated on a scale of unprecedented magnitude the value of well-planned fundamental textile research, coordinated with efficiently executed applied research and development. Such a compelling picture of the value of textile research did not exist in the industry before the war.

Second, our research program has of necessity directed attention to the study of the physical properties of textile fibers and fabrics and the fundamental laws governing their performance under many different conditions. In this field, which is peculiarly the responsibility of the textile industry, there has not heretofore been the contribution to scientific knowledge which has been made by the related chemical industries in the chemistry of textiles.

It is our belief that this demonstration of the value of research and of the area in which textile research is most needed today will serve to promote and stimulate further study of textile problems. We believe that by demonstrating this we have contributed toward the improvement of the living standards of the American people, as well as insured the availability for future emergencies of adequate technical development within the textile industry for coping with the problems of clothing armies in time of war.

Ideas for Manufacturers

THE 400-page report on "Wartime Technological Developments" submitted to Congress by the subcommittee on war mobilization, of which Senator Harley M. Kilgore is chairman, ought to fire the imagination of every manufacturer, and particularly of the manufacturer who marked time in the last five years if he was not producing an essential. Open the report at random and the eye falls on item after item with rich possibilities.

An aircraft plant distributes blueprints to the proper department in a way which has reduced blueprint production by 40 percent. A new chemical has been developed which makes it possible to convert cotton fiber and some cotton by-products into high-grade paper. By nickel-plating iron wires one company saves over 90 percent of the nickel formerly used in making incandescent lamps. Prefabricated steel-truss warehouses can withstand wind velocities and heavy snow loads far beyond requirements. There are 1,400 such ideas. Many can be applied immediately after the war; others will need more research and development.

Behind this report are larger considerations. The countless ways in which electronic devices can be used, the scores of methods of adapting plywood to any type of construction, the ingenious devices that have been invented to save material, time, and labor are bound to have a profound total economic effect. Will workers be displaced? The report is optimistic on that score. An invention like the automobile, radio, or air-conditioning creates satellite industries and thus increases employment. Very few of the conceptions presented belong in this revolutionary class, but Senator Kilgore is convinced that "an economy of expansion will stimulate constant improvements in products and in production methods."

The main point to be driven home is the manufacturer's need of a complete review of technological developments made in the last five or six years. The Kilgore report is not complete because much still remains a military secret, but its 1,400 items are more than good enough to give a resourceful business man ideas about reconversion.—*Editorial from The New York Times.*

Book Reviews

Economic Issues in Textiles—A Challenge to Research. Hiram S. Davis. Philadelphia, Industrial Research Department, Wharton School of Finance and Commerce, University of Pennsylvania, May, 1945. 32 pages. Price, $0.50.

(Reviewed by A. M. McIsaac)

This report emphasizes the need for thoroughgoing and comprehensive economic research to aid in formulating sound policies and programs for dealing with the post-war problems of the textile industry. It is designed to put these problems in a challenging perspective, and concentrates attention on those issues that, in the light of the author's long experience with the textile industry, appear to be of paramount importance both to the industry and to the public.

Although the emphasis is placed upon the need for further research as a guide both to industry and to government, the report should prove of immediate interest and value to current consideration of the industry's problems, since the major alternatives of policy are clearly outlined and their interrelationship is indicated.

The major questions to which the author has directed attention include: the trends in raw material prices, and the extent of public or industry controls over such prices; the prospective level of wage rates, and the factors affecting labor costs; the prospective returns on textile investments, in relation to post-war capital requirements; the prospects of foreign competition in textiles, and the implications of alternative foreign trade programs; the prospective extent and character of domestic demands for textile products; the problem of distribution costs and distributive channels; the possible developments in organization (vertical or horizontal combination) in the primary textile and related industries; and the possibilities of stabilization of textile production.

Over a fifth of the entire report is devoted to the significance of profits for the industry and to the discussion of prospective capital requirements. The difficulties of estimating the latter are indicated, the importance of matching depreciation policies with provisions for machinery replacement is underscored, and a warning is registered against the acceptance of a rapid installation of labor-saving machinery as a panacea for difficult price-cost relationships.

In the foreign trade field Mr. Davis recognizes the difficulties of adjusting our industries, and the textile industry in particular, to the conditions of a post-war world in which the United States has become the outstanding creditor nation. One interesting suggestion concerns the possibility that with the progress of industrial development in other countries a larger share of American textiles may be exported in the form of apparel and other finished goods, rather than as grey or finished cloth.

Concerning industrial organization, Mr. Davis notes some of the forces that have tended during the war to favor integration of successive processes in the textile industry. Although some of the forces may be temporary and underlying conditions may continue to favor separation of the various stages of primary manufacturing, converting, apparel manufacturing, and distribution, there is need for further study to see whether these basic conditions are changing.

Closely related to questions of organization in the primary textile industry and in textile distribution is the comparatively greater instability of primary textile production as compared with the consumption of finished textile products. Here again is an important field for investigation, and for the development of more accurate measures and indicators of trends in final textile consumption.

Plastics, Scientific and Technological. H. Ronald Fleck. Brooklyn, N. Y., Chemical Publishing Co., Inc., 1945. 325 pages + x. Price, $6.50.

(Reviewed by H. Mark)

This book intends to give a critical survey of the literature and a correlation of scattered data, which should be of value to the chemists in industry and to those who are in general interested in plastics. In the reviewer's opinion, it offers a considerable amount of factual knowledge and of theoretical considerations in comparatively few pages. It cannot

be said that the presentation is, at any instant, very deep or thorough-going, but this was obviously not the intention of the author and the publisher. The book is supposed to give a general survey of the plastics field and touch the high lights of practical application.

It begins with a short chapter on the history of plastics and has another on the availability of the most important raw materials. Then follows a brief discussion of the mechanism of polymerization, determination of the molecular weight of high polymers, and the organic chemistry of plastic materials. A short chapter on the manufacturing of plastic materials gives a very general idea of the general procedure in the most important cases. Next comes a description of synthetic rubbers, with the emphasis on the organic chemical aspect.

Chapters 7 and 8 discuss the physical properties of thermoplastic and thermosetting resins, while the following chapters deal with synthetic resins for coatings, synthetic fibers and textiles, and adhesives, with special emphasis on the fabrication of plywood and impregnated wood.

Then follows a description of molding, injecting, and extrusion practices, with a chapter on the chemical, physical, and electrical testing of plastics. The chemical analysis of raw materials and a few appendices (tables) complete the book.

This book can be recommended to anyone who wants to obtain first-hand, general information on the entire field of the industry of high polymers.

Spun Rayon Warp Sizing. New York, Textile Research Institute, Inc., 1945. 91 pages. Price, $1.50.

This is a summary report of a research project of the Textile Research Institute. The study was designed to throw light on certain problems peculiar to the sizing of staple rayon yarns. An investigation was made of the cohesive value of sizing materials, causes and methods of elimination of fiber shedding, production of desired "feel" and cover, ease of desizing, influence of residual sizing material on dyeing properties, and effects of slasher adjustments. It also included the investigation of possible test methods for anticipating the effectiveness of a sizing material by laboratory determinations on the sized yarns or fabrics.

The concluding part of the research was done as a joint project of the Institute and the Textile Foundation and consisted of a systematic study of the relationship between weaving efficiency and the film properties of warp sizing materials.

Although it was not within the scope of the project to perform weaving experiments on acetate yarns a study was made of some of the factors which influence the adhesiveness of sizing materials to acetate as well as to viscose rayon. The results of this study will be found in Part II of the report.

The results of this work suggest new techniques and methods of approach which will be equally applicable to studies with any system of warp sizing and will serve as foundation material for further research in this important field of textile manufacturing.

The Cotton Textile Industry of Fall River, Massachusetts: A Study of Industrial Localization. Thomas Russell Smith. New York, King's Crown Press, 1944. 175 pages. Price, $2.00.

(Reviewed by Robert B. Evans)

A combination of water power and water-front location provided the basis for the early nineteenth-century development of Fall River as an industrial and textile center. Low water transportation rates for coal and cotton, climatic conditions, and nearness to major cloth markets in New York, Philadelphia, and Boston led to Fall River's becoming the largest cotton-mill center in the country in the 1860's. Sales of print cloth, Fall River's specialty, were at a peak in 1900, after which a continued downward trend took place as the South, aided by lower wage rates and more automatic machinery, offered increasing competition. Since 1920, much of Fall River's textile equipment has been liquidated but a narrowing of the North-South wage differential, a change in local tax policy, influx of outside management, and a shift from staple fabrics toward finer, more highly styled constructions afford a basis for survival of part of the industry.

ABSTRACTS

SERVICES AVAILABLE

Reprints of the original articles abstracted in TEXTILE RESEARCH JOURNAL *are often available from the publishers. Otherwise, it may be possible to secure copies of the periodicals. A list of periodicals, the abbreviations used in references to articles, and the addresses of publishers of English language publications was given on page 22 of the January, 1945, issue. Orders should be sent direct to the publishers.*

Photostat negatives of articles abstracted will be furnished to members of the Institute at a cost of 15 cents per page for pages not exceeding 7 inches in width and 25 cents per page for larger sizes up to 11½ x 14 inches. Photostats of patents are 25 cents a page. Postage will be added.

Microfilm copies and paper enlargements of microfilm may be obtained from: Microfilms Inc., 313 N. First St., Ann Arbor, Mich.; New York Public Library, New York, N. Y.; Yale University Library, New Haven, Conn.; Harvard University Library, Cambridge, Mass.; and Library of Congress, Washington, D. C. Translations may also be obtained from the above sources.

ANALYSIS: TESTING: LABORATORY METHODS

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Absorption Spectra

Absorption spectra. II. Some aldehyde condensation products of methyl pyridines. E. R. Blout and V. W. Eager. *J. Am. Chem. Soc.* **67**, 1315–19 (Aug. 1945).

Curves are given for the ultraviolet absorption spectra of stilbene, 4-styrylpyridine, a number of substituted pyridines, and some of their benzene analogs. The relation between structure and absorption spectra is discussed. See also Blout and Gofstein, *J. Am. Chem. Soc.* **67**, 13 (1945). Absorption maxima are all between 300 and 400 mμ. That for stilbene is 295, and for 4-styrylpyridine, 307. A. R. Macormac

Alkyl Amines

Laboratory preparation of alkyl amines. J. B. Dickey. *Synthetic Organic Chemicals* (Eastman Kodak Co.) **17**, 1–5 (1945).

The practical synthesis of alkyl amines can be grouped under certain types of reactions. A typical example is given under each type, using a schematic type of presentation. J.

Cathode-Ray Oscillographs

Deflection sensitivity of parallel-wire lines in cathode-ray oscillographs. H. Gunther Rudenberg. *J. Applied Phys.* **16**, 279–84 (May 1945).

The deflection angle θ of a cathode-ray beam accelerated by a potential V is shown to be proportional to the linear charge density ρ transverse to the beam on the interior of the electrostatic deflection system, $\theta = \rho/2V\epsilon_0$. The voltage deflection sensitivity depends on the plate-to-plate capacitance c per unit width, $\theta/E = c/2V\epsilon_0$. This includes edge effects and permits a determination of the sensitivity from capacitance measurements or a simple graphical evaluation from the dimensions of the deflection system. The use of parallel-wire lines as a deflection system is suggested, and its deflection sensitivity evaluated. Such lines have low transit time error and are either easily tuned, or can be operated non-resonant with resistive termination. Author

Cellulose Estimation

Sodium chlorite as a reagent for the estimation of cellulose. P. B. Sarkar and H. Chatterjee. *Science and Culture* **10**, 340–2 (1944–5) (through *Bull. Inst. Paper Chem.* **15**, 367 (June 1945)).

Using a defatted jute containing 11.8% lignin and yielding 8.5% pentosans and 1.3% uronic carbon dioxide, the authors made comparative cellulose estimations by the Cross and Bevan, chlorine dioxide, Norman and Jenkins, and sodium chlorite-acetic acid methods. (The term "cellulose" is used to include residual hemicelluloses, and the authors appear to be unaware of Jayme's work.—Abstractor) The sodium chlorite procedure was the simplest method and gave the highest yields (89.03%) which, taken in conjunction with the lignin, accounted for the entire jute. The α-cellulose from the product obtained by sodium chlorite was 60.4% (on the initial sample).

Microscopy of Cellulose Fibers

Discussion on electron microscopy of cellulose fibers. W. Wergin. *Kolloid-Z.* **100**, 436–7 (Sept. 1942) —A reply to Frey-Wyssling's criticisms (Abst. 1637 (1944)) (through *Phys. Abstr.* **48**, 170 (June 1945)).

Optical Properties of Dyes

Crystal-optical constants of organic dyestuffs. II. Connection between the structure of organic dyes and the optical properties of their crystals. I. V. Riskin. *J. Applied Chem.* (U.S.S.R.) **14**, 1036–49 (1941) (French summary); cf. *C.A.* **35**, 3819[3]; **38**, 1367[8] (through *Chem. Abstr.* **39**, 4227[6] (Sept. 20, 1945)).

Optical properties of 28 various commercial dyes were examined. Organic solvents used for crystallization of the dyes do not, as a rule, affect the optical properties of the crystals. Optical properties can be used for identification of dyes. Structural changes produce definite

characteristic changes in the optical properties of the crystals.

Impregnation Rate of Fabrics

Determination of impregnating capacity of solutions and dispersions of hydrophobic substances. S. S. Voyutskii. *Legkaya Prom.* **1944**, No. 3, 26–7 (through *Chem. Abstr.* **39**, 4229[7] (Sept. 20, 1945)).

Three methods were developed as follows: (*a*) 0.1 cc. of test solution is placed on a 5-ply cloth and absorption of the drop is timed, (*b*) cloth as above is deposited on a surface of a standard dye solution and the appearance of pigmentation on the top surface is timed, (*c*) determination of actual amount of matter impregnated into the several layers of multi-ply cloth.

Stress Evaluation

Evaluation of rheological constants from tensile and compressive tests. W. Lethersich. *J. Sci. Instruments* **21**, 27–31 (Feb. 1944) (through *Kodak Mo. Abstr. Bull.* **31**, 81 (Mar. 1945)).

The behavior of a material in shear is deduced from purely tensile or compressive tests in rod specimens, by assuming that Poisson's ratio is known. A simple method of allowing for the change of cross section in tests at constant load is described.

Kreis Test

A modified Kreis test suitable for photocolorimetry. Morris F. Pool and Arthur N. Prater. *Oil and Soap* **22**, 215–16 (Sept. 1945).

A sensitive form of the Kreis test for rancidity in fats and oils is described, in which the reaction occurs in a one-phase system, which is suitable for direct photometric measurement. The procedure is convenient and rapid and yields reproducible results. Author

Stiffness Testing

The rigidity of textile fabrics. H. M. Taylor. *Paper-Maker* **109**, Ts40–2 (June 1945) (through *Bull. Inst. Paper Chem.* **16**, 40–1 (Sept. 1945)).

The author describes the narrow (1-in.) and the broad (6-in.) flexometers in use at the Shirley Institute for evaluating the stiffness (flexural rigidity, bending length, and bending modulus) of a textile material, which is one of the qualities involved in the evaluation of the handle of a fabric. Modifications for stiff and very limp fabrics and those which curl or twist badly, are described. The instruments and procedures were originally described in *J. Text. Inst.* **21**, T377–416 (1930).

Thermometers

Precautions in using thermometers. Constance. E. Arregger. *Can. Chem. and Process Ind.* **29**, 269–71 (Apr. 1945).

In high precision thermometry work, error may be introduced by radiation or conduction if emergent stem thermometers are used. If necessary to use this type, then it should be calibrated for total immersion and the formula should be used for the emergent stem correction, using a value of the emergent stem coefficient which has been found by experiment for that particular thermometer. E. G. Martin

Viscosity

A flow-curve recorder for a rotational viscometer. Ruth N. Weltmann. *Rev. Scientific Insts.* **16**, 184–91 (July 1945) (through *Bull. Inst. Paper Chem.* **16**, 41–2 (Sept. 1945)).

In the study of thixotropic substances and of materials of non-Newtonian behavior, it is important to obtain complete flow curves (rate of shear vs. shearing stress) which are taken in accordance with a standardized procedure. The time interval for any given increase or decrease in rate of shear should remain constant. A recorder which draws complete flow curves has been developed as an attachment for a Couette type of viscometer. The deflection of the bob, which is proportional to the shearing stress, is plotted against the speed (r.p.m.) of the cup, which is proportional to the rate of shear. For precise measurements, the bob suspension spring must not be subjected to any friction load; therefore, the recorder uses sparks generated by a high voltage to puncture the recording paper. The sparking electrode is moved by the bob deflection spring while the paper is moved perpendicularly to the electrode motion by the transmission handle, the position of which controls the cup speed. A number of measurements made with the recorder are shown. The recorded flow curves permit immediate interpretation and calculation (without any replotting) of the plastic viscosity, the yield value, and the thixotropic behavior of the tested materials. Also, a method is proposed for determining the plastic viscosity and the yield value at initial agitation, which are identified as "the initial thixotropic viscosity" and "the initial thixotropic yield value."

CHEMICAL AND PHYSICAL RESEARCH

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Absorption Spectra of Basic Dyes

Metachromasy of basic dyestuffs. L. Michaelis and S. Granick. *J. Am. Chem. Soc.* **67**, 1212–9 (July 1945).

Basic dyes which do not conform to Beer's law in aqueous solutions differ in their absorption spectrum with variations in solvent, concentration, and material dyed. It is generally agreed that such deviations are due to a reversible polymerization, usually the formation of a dimer. Curves are given for methylene blue, toluidine blue, oxonine, Capri blue, crystal violet, fuchsine, malachite green and phenosafranine, in alcohol and water, and on agar and nucleic acid substrate. The normal color of the dye occurs in the alcoholic and the dilute aqueous solutions and on the nucleic acid substrate; that of the dimer on the agar substrate and in concentrated aqueous solution. The addition of ammonium sulfate increases the tendency to polymerize. The absorption maximum of the

dimer lies at a shorter wave length than that of the monomer. In the presence of agar higher molecular aggregates are formed. Their absorption bands are still further displaced toward shorter wave lengths and are more diffuse. No polymerization takes place with nucleic acid substrate. Very little is known about the correlation of the chemical structure of a dye with its faculty of polymerization. This polymerization is always correlated with the metachromatic effect.

A. R. Macormac

Adsorption by Cellulose

Cellulose fibers: The sorption of organic vapors on cellulose fibers. K. Lauer. *Kolloid-Z.* **107**, 86–8 (May 1944) (through *Kodak Mo. Abstr. Bull.* **31**, 82 (Mar. 1945)).

Adsorption isotherms were determined for water, for methyl, ethyl, and *n*-propyl alcohols, acetic acid, carbon tetrachloride, and benzene on cotton and on viscose fibers. Changes of length, cross section, and volume were correlated with the adsorption values from both the vapor and the liquid phases. The amount of adsorption decreased from water through the alcohols to the pure organic liquids. At the same time the relative adsorption by hydrate and native cellulose, respectively, decreased from a ratio of approximately 2:1 to 1:1.

Rubber Antioxidants

Two modes of action of antioxidants in rubber. J. Le Bras. *Rubber Chem. Tech.* **18**, 22 (Jan. 1945).

Experiments are briefly described which indicate that antioxidants may function in either of the following ways: (1) As true antioxidants, retarding the rate of combination of oxygen with rubber; the oxygen which does combine, however, forms peroxides just as in the absence of antioxidants, with consequent deterioration of the rubber. (2) As deactivators, which transform rubber peroxides into oxides; the latter have little deleterious effect. Actual antioxidants tend to react by both mechanisms, but with one or the other predominating. It is shown by experiment, as might have been predicted on a theoretical basis, that a mixture of antioxidants of opposite types has much greater protective action than either one alone.

W. E. Davis

Oxidized Cellulose

Oxidized cellulose. C. C. Unruh. *Synthetic Organic Chemicals* **15**, 1943, 3 pp. (through *Kodak Mo. Abstr. Bull.* **31**, 88 (Mar. 1945)).

The action of oxidizing agents on cellulose usually gives nonhomogeneous and complex products. Periodic acid solutions, however, tend to oxidize the anhydroglucose unit specifically at the second and third carbon atoms, and nitrogen tetroxide apparently confines its oxidation action to the primary alcohol group to give a carboxylic acid.

Cellulose Acetate

Viscosity—molecular weight relation for cellulose acetate in acetone. W. J. Badgley. *Polymer Bull.* **1**, 17–19 (Apr. 1945).

Eight representative samples were chosen from a series of fractions obtained in the determination of the cellulose acetate distribution curve [Sookne, *J. Research Natl. Bur. Standards* **29**, 123 (1942)]. The curve obtained by plotting the log of the intrinsic viscosity $[\eta]$ against the log of the molecular weights, obtained by osmotic pressure measurements, may be represented by the empirical equation

$$[\eta] = KM^a - K'M^{2a}.$$

The values derived for the constants are: $K = 2.09 \times 10^{-5}$, $K' = 0.315 \times 10^{-10}$, and $a = 1.0$. Failure of the Staudinger and the Mark equations to describe the behavior of the high molecular weight fractions is thought to be due to increased curling of the molecules as the solvent power decreases.

A. R. Martin

Structure of Cellulose

Physical chemistry of the cellulose molecule. T. Svedberg. *Cellulosechemie* **21**, 57–72 (July 1943) (through *Abstract Bull.*, Kodak Research Laboratories (Apr. 1945)).

The author reviews the newer methods for studying the structure of cellulose materials: (1) in solid form by x-ray diffraction and (2) in solution by sedimentation velocity and equilibrium, diffusion, and streaming double refraction. The ultracentrifugal equipment is described in considerable detail. It is noted that to date definite molecular weights have not been determined by x-ray diffraction studies, and that sedimentation equilibrium measurements are not applicable for molecular weights above about 80,000. The results obtained by sedimentation and diffusion and by streaming double refraction are in good agreement for various celluloses and cellulose nitrates. Molecular weights of 2,550,000, 720,000, and 850,000 are given for unbleached and bleached cotton and wood cellulose, respectively. Of the materials studied, unbleached cotton gives the highest molecular weight and lowest polydispersity.

Cellulose Acetate Butyrate

Viscosity—molecular weight relations for cellulose acetate butyrate. J. W. Tamblyn, D. R. Morey, and R. H. Wagner. *Ind. Eng. Chem.* **37**, 573–7 (June 1945).

The relations between the molecular weights of fairly homogeneous fractions of cellulose acetate butyrate and the viscosity function $Ln\ \eta_r/c$ (determined in acetone and acetic acid) are given for two cases: (1) the limiting value as $c \rightarrow 0$, known as intrinsic viscosity; (2) the value at $c = 0.25$ gram per 100 cc. The establishment of a relation using the latter viscosity figure permits the determination of the viscosity—average molecular weight without recourse to extrapolation to zero concentration. Upon degrading samples of heterogeneous (unfractionated) cellulose acetate butyrate by heat, ball milling, and ultraviolet, it was found that the $Ln\ \eta_r/c$ values and the number-average molecular weights (from osmotic pressure) are also related by equations similar in form to those obtained on fractions. A means is thus at hand for obtaining the more

useful number-average of heterogeneous cellulose acetate butyrate from a single viscosity measurement. It is pointed out that the establishment of a simple relation between these quantities for any polymer depends on the kinetics of the polymerization or degradation process and its effect on distribution curves. Author

Structure of Cellulose Nitrate

Electron microscopic investigation of precipitates of cellulose nitrates. Gunnar Hambraeus and Bengt Ranby. *Nature* **155**, 200–1 (Feb. 17, 1945).

The electron microscope showed three main types of structure existing in precipitates of cellulose nitrates: (1) micellar structure, mainly from celluloses of about D.P. 1000, which the authors suggest is due to crystallites; (2) amorphous structure, or clumps without definite shape or magnitude, which is found in preparations of either very high or very low D.P.; (3) fine-grain understructure found as reticulate formations in nitrates of very low D.P. H. W. Theller

Degradation by Micro-Organisms

The incidence and control of mould and bacterial attack on textiles. R. G. Fargher. *J. Soc. Dyers and Colourists* **61**, 118–22 (May 1945).

Natural impurities as well as warp size present in grey cotton fabric encourage mold growth and account for the superiority of scoured cotton over grey in resistance to microorganisms. A large number of chemical treatments have been examined at the Shirley Institute for effectiveness in preventing mold growth. Conditions for test were 25°C and 92% R.H., these having been chosen as a compromise between the worst indoor tropical conditions and the optimum for mold growth. Salicylanilide and *p*-nitrophenol, which were judged to be sufficiently effective and met other requirements for general use in the textile industry, are the only treatments being extensively employed in England. An ideal rotproofing compound should protect the fabric from both chemical and biological tendering. In most climates chemical attack (by air, light, and moisture) predominates but biological attack, if contact with soil occurs, may take place much more rapidly. It is claimed by some that under trophical conditions serious contamination with decaying vegetable matter is inevitable and makes micro-organic growth the chief cause of degradation. Based on the assumption that loss in strength of cuprammonium-treated goods represents only chemical loss, a rough approximation of the relative effect of chemical and biological damage was obtained by the simultaneous exposure of grey and cuprammonium-treated goods for 12 mos. It was indicated that in hot, humid climates attack by microorganisms accounts for a considerable proportion of the total loss in strength. Flat, close-woven cloth with soft twist yarns is said to resist both types of deterioration better than more open or ribbed fabrics. The weather effect on grey cotton produces a gradual change which corresponds to the change from grey to bleached cotton, which explains why infection with microorganisms after long exposure is usually slight. Although acetylation of cellulosic materials and plastic coating (to reduce water absorption) show promise, the only more or less practicable agents for rot- and weather-proofing are copper and chromium applied by one of several methods. Mineral khaki dyeing satisfies to some degree the requirements for a rotproofing agent but should be applied to scoured rather than to grey cloth because the concentration of metal present is too small to afford protection to materials of high or even moderate susceptibility to mildewing. The resistance to leaching of copper during exposure cannot be found by laboratory leaching tests. Actual outdoor tests showed copper to be retained, after 5.38 in. of rainfall, best in the form of copper naphthenate or ricinoleate (about 75% retention) and poorest in the form of copper carbonate or cuprammonium (less than 15% retention). Chromium is retained to a much greater extent than copper. C.

Structure of Animal Fibers

Nature of animal fibers. III. Chemical and histological studies of the action of ammonia on human hair. E. Lehmann. *Melliand Textilber.* **24**, 1–6 (Jan. 1943) (through *Phys. Abstr.* **48**, 170 (June 1945)).

After 1 week in 25% aq. NH_3 human hairs showed no microscopical differences and the stretching and swelling capacities were little altered; the liquid contained yellow decomposition products of the melanine colors present, sulfides, and protein split-products. After more than 1 week, alkaline hydrolysis occurred, and this action was used to study fiber structure, since the least mechanical action then sufficed to break the fiber up into its fusiform cells. It is established that these are the ultimate units of which the fiber is built, and their structure is illustrated by photomicrographs. The cells have a slight tendency to twist, they fibrillate readily, and they are bound together in the fiber by an amorphous protein substance of as yet unknown composition. Pieces of the epidermal membrane are also found in the liquid and have a net-like surface structure. After 10 months the fiber has swollen to 200 times its original thickness, and if it is then dried it shrinks to 50% of the latter and gives an x-ray diagram similar to that of α-keratin.

Fiber Structure

Cellulose fibers: Fiber structure. K. Lauer. *Kolloid-Z.* **107**, 93–103 (May 1944) (through *Kodak Mo. Abstr. Bull.* **31**, 81–2 (Mar. 1945)).

The author gives a theoretical explanation of the physical properties of native and hydrate celluloses which have been discussed in the preceding six papers of this series (K. Lauer and coworkers: *J. makromolek. Chem.* **1**, 76, 97, 106, No. 1–6, Aug., 1943; *Monthly Abstr. Bull.* **31**, 42, Feb. 1945). Previous structural concepts are accepted; i.e., a spiral arrangement of molecules in native cellulose, whereas regenerated cellulose consists of bundles of molecules

and crystallites more or less oriented along the axis of the fiber; amorphous and crystalline regions are linked by primary valence chains and each cellulose molecule has both hydrophilic and hydrophobic surfaces. Water is bound to the hydroxyl groups in the amorphous region mainly by the interaction of permanent dipoles, whereas benzene, toluene, and pyridine are probably held by dispersion forces on the hydrophobic surface of the glucose residues. The difference in the relative wet strength of native and hydrate celluloses indicates that the surface of the crystallites of the native form is hydrophobic, and that of the hydrate form, hydrophilic.

Elasticity and Structure of Rubber

Rubbers and their characteristics: real and ideal. L. R. G. Treloar. *Nature* **155**, 441–4 (Apr. 14, 1945).

An address before the Royal Institution reviewing current ideas on elasticity and structure of rubber.

H. W. Theller

Coefficient of Friction of Wool

Frictional properties of wool fibers. E. H. Mercer. *Nature* **155**, 573–4 (May 12, 1945).

Coefficients of friction (μ_2 and μ_1) of single wool fibers were evaluated with and against the scale direction. The directional coefficient $\mu_2 - \mu_1/\mu_2 + \mu_1$ was found to increase upon wetting the fiber, and the increase was greater in acid and alkaline than in neutral media. Shrinkage-reduction processes reduce the directional friction in alkaline solution.

H. W. Theller

Infra-Red Spectroscopy

Application of infra-red spectroscopy to chemical problems. Anon. *Nature* **155**, 191–3 (Feb. 17, 1945).

A summary of a Faraday Society symposium. Applications of infra-red spectroscopy to problems of structure and composition of high polymers are included.

H. W. Theller

Effect of Iodine on Wool

The action of iodine on wool. S. Blackburn and H. Phillips. *J. Soc. Dyers and Colourists* **61**, 100–103 (Apr. 1945).

Wool reacts rapidly with aqueous solutions of iodine (0.001*N* to 0.1*N*) in potassium iodide at room temperature. The iodine taken up (0.2% to 16%) may be divided into portions corresponding with absorbed, anionic, and combined iodine. The amount of absorbed and anionic iodine increases as the concentration of the iodinating solution increases. For any given iodine concentration the amount of absorbed and anionic iodine decreases with increase in pH of the solution. It is suggested that the anionic iodine and absorbed iodine form a complex polyiodide with the basic side chains of the wool. The combined iodine, which under suitable conditions constitutes only a small part of the total iodine taken up, probably represents substitution of the iodine in the tyrosine groups of the wool. The rate of removal of absorbed iodine from wool on exposure to air at 37°C and on treatment with solutions of detergents has been determined. Author

Reactivity of Oxycellulose

Cellulose studies: I—Reaction of oxycellulose with aqueous acid and alkalies. Eugene Pacsu. TEXTILE RESEARCH JOURNAL **15**, 354–61 (Oct. 1945).

The behavior of the aldehyde type of oxycellulose prepared by the action of 1 mole of sodium metaperiodate on cotton was investigated. Treatment of the oxycellulose with 2*N* hydrochloric acid at room temperature caused no apparent changes in the properties of the material. The comparatively great resistance to acid of the C-O-C linkages in oxycellulose deserves special consideration in view of the widespread belief concerning the harmful effect of acids on oxidized cellulose. The enhanced reactivity of the aldehyde type of oxycellulose in alkaline media presents difficult problems. Numerous reversible and irreversible changes may take place in the presence of hydroxyl ions. Because of these changes, an aqueous solution of periodate oxycellulose, although practically neutral to litmus, uses up a considerable quantity of standard alkali solution, without, however, having a sharp end-point in the presence of phenolphthalein. Therefore, methods of determination of the *supposed* carboxyl content of the aldehyde type of oxycellulose by direct or indirect use of alkali are fundamentally unsound. The cause of the acidic behavior of periodate oxycellulose in alkaline solution is sought in the anionotropic and prototropic changes which may conceivably take place. An anionotropic change involving the transfer of a hydride ion from one aldehyde group to the other within one dialdehyde unit of the chain (Cannizzaro reaction) should give an essentially undegraded product having a probably random distribution of glyoxylic acid and glycolaldehyde acetal units. Experimental evidence, however, indicated that periodate oxycellulose, in the presence of 1 mole of dilute alkali and *without* subsequent acid hydrolysis, suffered an almost complete degradation. This behavior leads directly to a consideration of the prototropic changes as the second type of transformation which may take place in alkaline media. Because of the presence of $=CH-\underset{|}{C}=O$ groupings in the aldehyde type of oxycellulose, the substance must be in equilibrium with the tautomeric enol-form which, on account of the glyoxal part of its units, represents a "hydroxyketene acetal" of acidic character. Now it is known that negatively substituted ketene acetals hydrolyze rapidly to the corresponding esters in pure water or even in alkaline media by the loss of 1 mole of alcohol. It is, therefore, concluded by the author that the enolate ion of the aldehyde type of oxycellulose is instantaneously cleaved by an electrophilic attack of the water molecule which, by a displacement mechanism, breaks one of the C—O—C linkages to yield the enol-form of glycolic acid ester. The latter is subsequently hydrolyzed through the well-known mechanism for base-catalyzed hydrolysis to give rise to the sodium salt of glycolic

acid and erythrose, which is then decomposed in the alkaline medium. All these reactions leading to the complete degradation of the oxycellulose may take place simultaneously as competing reactions. On the basis of this working hypothesis the ageing of alkali cellulose can also be interpreted. The author believes that most of the oxidizing agents, oxygen in alkaline medium being one of them, attack the glucose anhydride units of the cellulose in the same fashion as periodic acid does. The dialdehyde units so formed are at once cleaved in alkali through the mechanism outlined above. The result is a cellulose with shorter chains and more end groups, hence with high copper number and low viscosity. Evidently, complete elimination of the aldehyde type of oxidation by the use of suitable bleaching or oxidizing agents should result in improved fibers which would not deteriorate rapidly in even a mildly alkaline medium such as a soap solution. On the other hand, if the employment of bleaching or oxidizing agents which produce the aldehyde type of oxycellulose is unavoidable, then the use of some neutral or slightly acidic detergent instead of soap would be most advantageous.

Author

Polyamides from Fatty Acids

Polyamides from polymeric fat acids. L. B. Falkenburg, H. M. Teeter, P. S. Skell, and J. C. Cowan. *Oil and Soap* **22**, 143–8 (June 1945).

The preparation and properties of various polyamides, copolyamides, and modified polyamides of polymeric fat acids are described. These polymers are of interest because of their unusual properties and because of the unsaturation and relatively high molecular weight of the polybasic acids involved. Despite the presence of tribasic acids in polymeric fat acids, ungelled polymers having molecular weights of 3,000 to 5,000 are obtainable. A brief discussion is given concerning the application of theoretical principles of polymerization to the preparation of these polymers. Possible industrial uses for the polyamides are indicated. Author

Polystyrene

Polystyrene. Stanley Booth. **Part I.** *Brit. Plastics* **17**, 130–36 (Mar. 1945). **Part II,** *ibid.*, 172–81 (Apr. 1945). **Part III,** *ibid.*, 200–6 (May 1945).

Part I is a review of the manufacture of styrene and its polymerization, with 50 references. Part II reviews the structure, molecular weight, molecular weight distribution, effect of the latter on physical properties, and the electrical and physical properties of polystyrene, together with 32 references. Part III concludes the series with a review of the processing of polystyrene. 8 references. E. F. Evans

Reversible Denaturation of Proteins

Denaturation and renaturation of proteins. D. Coleman and F. O. Howitt. *Nature* **155**, 78–9 (Jan. 20, 1945).

A study of the solution of silk fibroin in cupriethylenediamine and its subsequent regeneration showed it to be capable of reversible denaturation. It is claimed that complete renaturation is demonstrated here for the first time. The results suggest that, with fibroin, denaturation consists simply in the unfolding of a molecular chain. H. W. Theller

Synthetic Protein Fibers

Synthetic protein fibers from protein-detergent complexes. Harold P. Lundgren. TEXTILE RESEARCH JOURNAL **15**, 335–53 (Oct. 1945).

The application of long-chain hydrocarbon salts in the conversion of proteins into oriented fibers is discussed at length. Chemical and physical data are presented which show that the reaction of a model protein (crystalline egg albumin) with alkylbenzene sulfonates and alkyl sulfates occurs in two steps: the first involves an ion exchange in which the anions on the protein basic groups and the cations of the detergent salt are replaced, resulting in the formation of a protein-hydrocarbon salt; the second step is a combination, through weaker forces, of the protein-hydrocarbon salt with additional hydrocarbon salt. The presence of the double combination of hydrocarbon salt contributes a characteristic flow property to the protein, making it suitable for spinning. All of the hydrocarbon salt is recovered from the spun fibers by extraction with 60 to 70% aqueous acetone. Recovery of the weaker-bound salt occurs directly, while the ionically bound salt requires an inorganic salt to supply the ions necessary to reverse the exchange reaction.

Details of the preparation of oriented fibers from technical egg white and from dispersed chicken feathers, including a description of laboratory spinning equipment, are given, together with a description of some of the properties of the fibers prepared in this manner. Author

Serine

Amino acids. IV. Amino acids related to serine. J. H. Billman and E. E. Parker. *J. Am. Chem. Soc.* **67**, 1069–70 (July 1945).

Three beta-hydroxy-alpha-amino acids related to serine have been prepared from the corresponding amino alcohols. Attempt to obtain serine by decarboxylation did not produce pure serine.

A. R. Macormac

Urea-Formaldehyde

Condensation of formaldehyde with urea and melamine—Part I. William Feast. *Brit. Plastics* **17**, 36–44 (Jan. 1945). **Part II,** *ibid.*, 66–73 (Feb. 1945).

Part I is a review and discussion of the probable structures of the primary and secondary condensates of urea and formaldehyde. Part II concludes the series with a discussion of the structures of urea-formaldehyde resins, melamine-formaldehyde condensates, and resins, melam, melem, mellon, and alkylated resins.

E. F. Evans

Wettability

Wettability of porous surfaces. A. B. D. Cassie and S. Baxter. *Trans. Faraday Soc.*, **40**, 541–51, Dec., 1944.

The analysis of apparent contact

angles for rough surfaces is extended to porous surfaces, particularly those encountered in natural and artificial clothing. Formulae are derived for the apparent contact angles, and experimental data confirming the formulae are given. Water-repellent clothing structures are discussed by means of this analysis, and it is shown that the water-repellency of the duck is due to the structure of its feathers rather than to any exceptional proofing agent. J.

FIBERS: YARNS: FABRICS: MECHANICAL PROCESSES

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Animal Fibers

The South American cameloids. A. C. Whitford. *Textile Age* **9**, 70, 72, 74 (Aug. 1945).

An article describing two South American animals, the guanaco and the llama, and fiber characteristics of their fleece. The former run wild and must be hunted; the latter are domesticated. H. J. Burnham

Cottonized Bast Fiber

Cottonized bast fiber. J. B. A. Stroink, H. J. Bendel, and D. A. Beerens. *Melliand Textilber.* **25**, 181–3 (1945) (through *Chem. Abstr.* **39**, 4228[5] (Sept. 20, 1945)).

Fundamentals of cottonization are described. Eight requirements which a product must meet in order to be satisfactory are outlined and discussed in detail, with consideration of chemical and physical factors.

Glass Fiber Properties and Structure

Glass-fiber investigations. Introduction, definitions, general problems. Hans Freytag and Paul A. Koch. *Glastech. Ber.* **21**, 7–13 (1943); *Chem. Zentr.* **1943**, I, 2126–7 (through *Chem. Abstr.* **39**, 3407[4] (Aug. 10, 1945)).

The technical terms are standardized and an attempt is made to correlate properties with glass surface and structure. Internal forces are interpreted according to Smekal's theory. Comparisons are made with organic fibers. A long bibliography is included.

Protein Fibers

Synthetic fibres from vegetable proteins. D. Traill. *J. Soc. Dyers and Colourists* **61**, 150–5 (June, 1945).

Groundnuts (peanuts) and soya beans are from an economic point of view the most favorable starting materials for the production of protein synthetic fibers. To produce protein from groundnuts the usual method of oil extraction, in which the nuts are heated, cannot be used as this denatures the protein and renders it unsuitable for the production of fibers. A solvent extraction process is therefore used. Protein solution suitable for spinning may be prepared from the groundnut meal remaining after extraction of the oil from the nuts by treatment with sodium hydroxide. The pH of the fresh solution must be at least 12.5 and there exists an optimal protein concentration, usually 20–30%, for each sample of globulin. The fiber is formed by extrusion of the solution into a bath of sodium sulfate and sulfuric acid, followed by hardening in a solution of sodium chloride, hydrochloric acid, and formaldehyde. The fibers are thoroughly washed and adjusted to pH 8 so that they will dye evenly with wool. The physical properties (including wear resistance and insulation value) and dyeing properties, and the potentialities of peanut fiber (Ardil) in admixture with wool and viscose, are discussed. C.

Artificial protein fibers: Their conception and preparation. W. T. Astbury. *Nature* **155**, 501–3 (Apr. 28, 1945).

A brief review, pointing out the important role which x-ray diffraction analysis has played in furnishing the fundamental knowledge of protein crystal structure, which was the basis for the development of such artificial protein fibers as Ardil. 16 references. H. W. Theller

Ramie Production Possibilities

The possibilities of ramie. *The Chemurgic Digest* **4**, 137, 139–45 (Apr. 30, 1945).

This discussion of ramie was adapted from a staff report of the Office of Production Research and Development, War Production Board. Ramie (*Boehmeria nivea*) long has been known in the Orient and small quantities have been imported into the United States. It is grown commercially in China, Sumatra, Japan, and India, and has been raised successfully in the Philippines, Mexico, Haiti (where it is irrigated), and in the southern part of the United States, particularly in Florida and along the Gulf Coast. Extensive use of ramie has been hindered by difficulties in decorticating the stalk, so as to separate ramie fiber, and in degumming it. The Corona machine, designed by the Krupp works for decorticating sisal leaves, has been used successfully on ramie in Haiti during 1943 and 1944. Other decorticating machines also are said to operate successfully. Degumming has been accomplished by digesting air-dried ribbons of ramie under pressure in a caustic soda solution. Data regarding tensile strength, elasticity, absorbency, and other properties are presented. Uses mentioned include mechanical packings, parachute harness webbings, upholstery fabrics, filter cloths, incandescent gas mantles, and filter cloth. Production cost for decorticated, degummed fiber, grown in the Everglades, is estimated at as low as 9¢ per pound. An extensive bibliography is given. R. B. Evans

Ramie: a new economic opportunity. Earl L. Rauber. *Monthly Review* of the Federal Reserve Bank of Atlanta **30**, 57–62 (June 1945).

Currently more than 1,600 acres are planted with ramie in Florida and upwards of 10,000 additional acres have been set aside for the same purpose. Ramie is a perennial and three or more cuttings can be obtained per year, the Florida acreage yield being approximately 45 tons of green material, from which 1,200 to

1,500 lbs. of fiber can be obtained. The remainder of the green material can be returned to the soil as fertilizer or converted into livestock feed. Entirely satisfactory cost figures are not available, but two estimates on the basis of experimental conditions give total costs as 9.1¢ and 10.1¢ per pound. These totals are divided into 3.0¢ and 3.3¢ for growing the ramie, 3.6¢ and 1.7¢ for the decortication operation, and 2.5¢ and 5.5¢ for degumming the fiber. Undegummed ramie fiber is said to have been sold for 25¢ per pound before the war while degummed fiber sold for 40¢ per pound and higher. Possible uses of ramie and opportunities and implications involved in ramie culture in the South are considered. R. B. Evans

Viscose Rayons

High-tenacity viscose rayons. L. Rose. *J. Soc. Dyers and Colourists* **61**, 113–17 (May 1945).

The manufacture, physical properties, dyeing properties, and uses of a moderately high-strength normal-extensibility viscose rayon ("Tenasco") and a very high-strength low-extensibility viscose rayon ("Durafil") are described. A new type (called "textile Tenasco") of slightly lower strength than Tenasco but with properties more suited to normal textile processing is also discussed. Applying stretch to freshly formed viscose filaments increases their tenacity and reduces breaking extensibility. Reduction of extensibility below 12% produces a fiber of generally lower serviceability. However, even with maximum stretch, 11% extensibility is about the lowest obtainable in the ordinary viscose process, this figure representing contraction after the material enters the centrifuge box and also the contraction accompanying regeneration to cellulose. The composition of the coagulating bath is capable of altering the "inherent extensibility" and under optimum conditions (with a water bath at 90°C between the godets) using maximum stretch a filament having a tenacity of 3.6 grams per denier and 17% extensibility is produced (Tenasco). In the production of "Durafil" the viscose, as in the long-known Lilienfeld strong-acid process, is extruded into 65% sulfuric acid, then quenched immediately in cold water, regenerating cellulose very rapidly, and processed as ordinary viscose yarn. The resulting filament consists of an outer shell of highly crystalline cellulose and a more amorphous inner core. By reducing the denier per filament the fiber ultimately consists almost entirely of shell; production is therefore standardized at 0.3 denier, realizing the highest possible strength (about 5.6 grams per denier). X-ray photographs show the orientation of Tenasco to be quite good and that of Durafil to be excellent. Stress-strain curves are shown for dry, wet, and knotted threads of ordinary viscose, Tenasco, and Durafil; the yarns in the order named lose 50, 40, and 33% of their strength when wet. Increased orientation evidently leads to reduction in resistance to shear as well as to reduced knot tenacity. The rate of dyeing of Tenasco depends upon the balance between the tendency toward rapid dyeing conferred by the "high extensibility coagulant" used and the lowered rate caused by increased orientation of the fibers. In Tenasco for tire cord the second factor has more weight and the product is slow-dyeing, whereas in textile Tenasco, even though it is more highly oriented than ordinary viscose, the first factor predominates and it is rapid-dyeing. Durafil dyes at a lower rate than ordinary viscose, but comparable data are not possible since the latter type cannot be spun as fine as the standard Durafil. Heavy shades can be obtained only with direct dyes on Durafil, with dyes which have a low time of half-dyeing. Vat dyes may be applied even to the extent of 50%, although the cost is prohibitive. Because finer filaments require more dye for the same depth of shade, Tenasco costs about 50% more and Durafil at least four times more to dye than ordinary viscose. Azoic and developed dyes may be used satisfactorily. Textile Tenasco is expected to be the standard viscose of the future. Durafil has been used for insulating fabric; for parachutes it is inferior to Tenasco because of its low extensibility (about 7%). It has potential use in plastics, power belting, and in superfine cloths. The great use for Tenasco is in tire cord, where its properties result in a tire which under severe conditions heats up less than one with cotton cord and therefore deteriorates at a lower rate. It has a strength advantage over cotton for this use since it is about 30% stronger at 0% R.H. than at 65% R.H., whereas cotton is about 20% weaker. Improved cord performance also results in a saving in rubber. Because of the low extensibility of Durafil it loses more strength than Tenasco at the high twist necessary to give flexing life to tire cord and is consequently unsuitable for this product. C.

Synthetic Fibers

The case for synthetic textiles—Part III. Anon. *Modern Plastics* **22**, 95–101, 204, 206, 208, 210 (Mar. 1945).

The third part of the article deals with plastic finishes of textiles, including a discussion of developments in water-repellent finishes, wool that will not shrink, plastics in printing and dyeing, crease-resistant fabrics, and resin finishes to create special effects.

Processing Water-Repellent Fibers

The application of solubility phenomena in the processing and use of water-repellent textile fibers. (Cellulose acetate, nylon, vinyl fibers.) Gaston Mouchiroud. *Teintex* **8**, 203–13 (1943); *Chem. Zentr.* **1944, I**, 71 (through *Chem. Abstr.* **39**, 3671[9] (Aug. 20, 1945)).

Topics considered include: the most satisfactory behavior of water-repellent fibers toward water; the behavior of acetate rayons in the dyeing process as regards their ability to swell in certain solvents and solutions; similar behavior of nylon; printing and discharge printing of acetate rayon; the resistance of acetate rayons to carbonization with HCl and the possibility of removing

such fibers by the use of solvents; the decomposition of acetate rayon by Al perchlorate (in contrast to the ineffective $AlCl_3$); and the resistance of nylon to the perchlorate.

Light Stability of Silk

The light stability of natural silk and methods for improving it. K. M. Markuze and S. N. Tyuremnova. *Shelk* **10**, 18–20 (1940); *Chem. Zentr.* **1941, II**, 1697 (through *Chem. Abstr.* **39**, 3936[8] (Sept. 10, 1945)).

Natural silk is very light-sensitive and in the presence of moisture and air is easily weakened by ultraviolet or visible sunlight. The tensile strength is reduced by 30% and the elongation by 40% of their original values on 20 days' exposure to the summer sun. Various chemicals, dyes, etc., improve the retention of tensile strength. It is shown that treatments of dyed silk with tannin followed by tartar emetic, or with thiourea followed by HCHO are effective. A solution of NH_4CNS (10 g./l.) also gives improvement.

Moisture Relations of Textile Fibers

The moisture relations of textile fibers. "Chemitex." *Silk J. Rayon World* **21**, 35–7, 42 (July 1945).

An extensive review, including tables showing moisture regain of textile materials, wet strength of textile fibers, breaking load at various humidities, extension at break (dry and wet), percent extension at break at different humidities, dimensional changes with humidity, change in area of cross section from 65% relative humidity to wet, and imbibition of water. Original references are not given. R. K. Worner

Coated Yarns

Plexon—plastic coated yarn. N. J. Strauss. *Plastics and Resins* **4**, 7–8, 32 (June 1945).

A brief description of the preparation, properties, and uses of plastic coated yarns. It is predicted that the present range of diameters, 0.008–0.090 in., will be greatly expanded and yarns fine enough for dress goods and hosiery may be forthcoming. A. R. Martin

Slasher Drive

Tension in slashing controlled electrically. R. B. Moore. *Textile World* **95**, 115, 117, 186, 188 (Aug. 1945).

A description of the G. E. constant tension slasher drive in which the beam is driven by a D.C. adjustable speed motor with constant horsepower characteristic. Motor current is directly proportional to tension and is held constant at any predetermined value by a suitable regulator. An ammeter in the motor circuit gives a direct indication of the tension value. The D.C. input to the wind-up motor is furnished either by a special rotating excitor, such as the amplidyne, or by electronic equipment. H. J. Burnham

Spun-Rayon Slashing

Spun-rayon warps more difficult on silk system. Raymond Dodson. *Textile World* **95**, 129, 174, 176 (Aug. 1945).

Practical hints on slashing spun rayon on the silk system, which is more difficult and troublesome than on the cotton system. It is recommended that the ends be split into layers during warping and that tension be kept low during slashing. Basic size formulas are given for 100% rayon spun on the cotton system and on the worsted system, 100% spun acetate, and 50–50 rayon-wool blend. H. J. Burnham

Warp Knitting

Warp knitting. W. E. Boswell. *J. Text. Inst.* **36**, P41–5 (Apr. 1945).

A lecture designed to give a general outline of warp knitting machines and the fabrics they produce. Some attention is given to the elements controlling fabric design and structure. A. R. Martin

Warp Tying Machine

Automatic warp tying for the textile industry. Anon. *Silk and Rayon* **19**, 424–5 (Apr. 1945).

A new warp tying machine with modifications and improvements is described and claimed to be the most efficient warp tying machine in existence. A feature characteristic of the clamps used with this machine is that they are designed for ready alignment of the two sets of threads. By employing special shielded needles fixed to oscillating levers, the detachment of one thread from each layer is ensured, and automatic adjustment of the machine in relation to the warp is possible. In conjunction with the detaching needles, a lease detacher ensures that only the outer thread from each lease will be selected and passed on for tying. An important feature is the suspension of the knotted ends on a cord, which enables supervision of the work. As the knotted threads are taut on the cord, it is possible to tie crepe warps. The machine operates with maximum efficiency when tying at a rate of 12,000–15,000 knots per hour. A. L. Merrifield

Nylon

Nylon yarns. [British Nylon Spinners Ltd.] *Silk J. Rayon World* **21**, 25–6, 39 (May 1945).

Abstract of booklet "Nylon Yarn—Its Properties and Its Processes." Comparative data are given for nylon and other textile fibers on specific gravity, strength and elongation, elastic properties, abrasion resistance, moisture regain, swelling and shrinkage characteristics, water-extractable material, and chemical resistance. R. K. Worner

Twist Take-Up

The take-up due to twist in acetate yarns. H. R. Mauersberger. *Rayon Text. Mo.* **26**, 74–75 (Feb. 1945).

Data are presented showing the take-up due to twist of a number of acetate yarns ranging from 55 to 300 denier. The data cover the range 5–50 t.p.i. in increments of 5 t.p.i. A. R. Martin

Electrocoated Fabrics

Electrocoated fabrics process now ready for commercial application.

Anon. *Textile Bulletin* **68**, 23 (Aug. 15, 1945).

A report on a joint project by Behr-Manning of Troy, N. Y., and General Electric, whereby loose fibers sent through an electrostatic field set up by high-voltage electrical equipment receive a charge of the same polarity as an electrode at the bottom of the field and are hurled upward perpendicularly into an adhesive-coated "backing" fabric, paper, or cellophane run simultaneously through the field. Ends of the fibers are buried in the adhesive and the resultant electrocoated fabric is conveyed through a dryer for "curing." Patterns can be printed with adhesive on the "backing" fabric and fibers will cling only where the adhesive appears. A concentration of 300,000 fibers per sq. in. has been attained. It is claimed that durability tests show ratios of 3 : 1 in favor of electrocoated fabrics over woven fabrics. Commercial applications are said to include women's dresses, scarfs, neckties, overcoats, draperies, bedspreads, bath mats, upholstering material, rugs and carpeting. [An article describing this process was published in TEXTILE RESEARCH **12**, 2 (Feb. 1942).—Ed.]

H. J. Burnham

Fiberglas Textiles

Potentialities of Fiberglas textiles. G. Slayter. *Am. Dyestuff Reptr.* **34**, P189–90, 193 (May 7, 1945).

The manufacture of continuous filament and staple fiber-glass yarns is briefly discussed. High-speed drawing of the soft filaments onto a winder produces filament yarn; the action of jets of high-pressure steam is used to literally yank emerging streams of glass into staple fibers from 8 to 15 in. in length. Average Fiberglas diameters range from 22 to 38 one-hundred-thousandths of an inch and have a tensile strength in the order of 300,000 lbs. per sq. in. Experimental fibers have been produced of one-tenth this diameter and with ten times the strength. Properties encouraging the use of Fiberglas are high tensile and tear strength, dimensional stability, moisture resistance, inertness toward chemicals, dielectric properties, and incombustibility. Fiberglas cannot be used for applications requiring repeated flexing or friction, such as those necessary for upholstery or apparel. It can, however, be twisted, plied, and woven on adaptations of standard textile machinery. C.

Spun Rayon

Fine spun viscose plain weave fabric. Anon. *Am. Wool and Cotton Reptr.* **59**, 11–12, 16 (Sept. 6, 1945).

A prediction that new spun rayon fabrics will use fine 2-ply yarns made from high-tenacity fibers of finer denier and shorter length than are now common. A sample cloth construction is given using 80/2 yarns with 88 × 88 plain weave with estimated cost breakdown.

H. J. Burnham

Rayon-Cotton Fabrics

Converting rayon-cotton fabrics. Irving Teplitz. *Rayon Text. Mo.* **26**, 67–8 (Feb. 1945).

A brief description of the role of the converter in the textile industry. A number of important rayon-cotton fabrics are described in some detail.

A. R. Martin

Rayon Pile Fabrics

Features in the construction of rayon pile fabrics. Anon. *Silk and Rayon* **19**, 670, 672–4 (June 1945).

The weaving of pile cloths, constructed completely of rayon fibers, has introduced variables that require considerable skill; particular attention to the methods employed in preparing the yarns; and the adjustments of the loom for weaving. These features and other controlling factors are discussed in general. The proper loom settings are described and illustrated with diagrams. A. L. Merrifield

Rayon Tire Fabric

The manufacture of rayon tire fabric. Anon. *Rayon Text. Mo.* **26**, 72–3 (Feb. 1945).

A brief illustrated description of the method of manufacturing rayon tire fabric at the American Viscose Corporation's Parkersburg, W. Va., plant. A. R. Martin

Rubberized Fabric

Rain clothing from rubberized rayon. Kehren. *Allgem. Textil-Z.* **1**, 242–6, 283–6 (1943); *Chem. Zentr.* **1944, II**, 86–7; cf. *C.A.* 39, 624 (through *Chem. Abstr.* **39**, 3935 (Sept. 10, 1945)).

The cloth is rubberized on one or both sides, or two pieces are cemented together with rubber. Wet strength of rayon is less than that of cotton, it is not increased by the rubberizing treatment, and it steadily decreases on exposure to rain.

Trends in Fabric Construction

Recent developments in synthetic fibers and their use in fabrics of the future. R. Bouvet. *Am. Dyestuff Reptr.* **34**, P187–8, 193 (May 7, 1945).

Probable trends in fabric construction in the post-war era based on technical developments in the synthetic fiber industry are discussed.

C.

Water Repellency

The water repellency of fabrics and a new water-repellency test. S. Baxter and A. B. D. Cassie. *J. Text. Inst.* **36**, T67–90 (Apr. 1945).

The production of efficient water-repellent fabrics is of great practical importance. The conventional method is to weave a fabric from tightly twisted yarns so that the warp and weft tie as closely together as possible, and then to give the fabric a water-repellent treatment. Such a trend in the design of water-repellent fabrics has probably, to a large extent, been influenced by the use of the hydrostatic pressure test as a means of measuring water repellency, since it is well known that thin, tightly woven fabrics, if properly proofed, give a high breakdown pressure. Much trouble has been encountered in the past by the con-

flicting results obtained from the different water-repellency tests in assessing fabrics of the same structure, when treated with different proofing agents, and also when attempting to assess the water-repellent properties of different types of fabric. This is due to the fact that the various methods of testing do not necessarily measure the same properties of the fabrics. In the present paper an analysis is made of the properties measured by different tests and the results are compared with the mechanism by which rain is absorbed by a fabric. A new apparatus designed to measure a fundamental property of rain-resistant fabrics is described. Results obtained using this test, together with a study of natural water-repellent surfaces, such as ducks' feathers, have shown clearly that the conventional water-repellent fabric has a structure far from ideal. The theoretically ideal structure for a water-repellent surface is explained.

Author

Cramerton Comber

Novel features in new comber at Cramerton Mills. Anon. *Cotton* **109**, 102–3 (Aug. 1945).

A description of a new cotton comber developed by Cramerton Mills, Inc., Cramerton, N. C., featuring automatic lap changing and doffing. Lap weight is 1,400 grains per yard and production is claimed to be 36 to 40 lbs. per hour at 94 to 98% efficiency. Noils are taken directly to the waste house by means of conveyor pipe and condenser. Top roll weights are replaced by springs. The comber is a 6-head, one-sided machine. H. J. Burnham

Cotton Slashing

Some studies on cotton warp sizing. Paul Gulledge. *Cotton* **109**, 95–8 (Aug. 1945).

A description of mill tests to determine weaving qualities of yarns sized with different starches and sizing compounds. These are not identified, since the article is intended merely to point out methods of practical mill testing. Emphasis is laid on checking running conditions in the weave room rather than laboratory tests. H. J. Burnham

Textile Drying

Recent developments in the drying of textile materials. C. N. Rabold. *Am. Dyestuff Reptr.* **34**, P108–10 (Mar. 12, 1945).

Modern methods of textile drying, including the latest trends in radiant energy and dielectric drying, are briefly discussed. For the most satisfactory curing of resin and durable water-repellent finishes, temperatures in excess of 375°F are desirable; since about 360°F is the maximum obtainable from the average steam plant, indirect fired or infrared equipment may be employed to advantage in conjunction with steam installations to obtain higher temperatures. Many advantages are cited for independent infra-red drying units. A transcript of an extended discussion of textile drying is appended. C.

Wool Drying Machine

A modern wool drying machine. Donald Wilson. *Textile Recorder* **62**, 41–2, 51 (June 1945).

A new multiple fan wool drying machine is described. This machine is a departure in wool drying machinery, in that it can be readily altered by the operator to operate under any of the following conditions: (1) decreasing temperatures from the feed end, (2) increasing temperatures from the feed end, and (3) uniform temperature throughout the drier. This variability in the drier is an advantage, particularly since it may be employed for carbonizing as well as wool drying. The drier requires an automatic feeder to ensure a uniform thickness of wool on the perforated mild steel conveyor sheet. Each section of the drier has an individual steam chest and fan unit, which controls the temperature and direction of hot air flow. This drier is economical in consumption of steam ($1\frac{3}{4}$ lbs. of steam per lb. of moisture evaporated), power, and labor. It is also suitable for drying different qualities, or colors, of material, as one lot can follow the preceding lot without mixing, since the internal construction is such that the fibers cannot cling to the machine parts. A. L. Merrifield

Warp Knitting

Warp knitting. Thomas H. Johnson. *Silk J. Rayon World* **21**, 29–30 (May 1945); *Can. Text. J.* **62**, 37–8, 54 (Apr. 6, 1945).

Warp knitting is described as "that process of knitting in which the threads follow a general warpwise direction in the fabric, regardless of whether the cloth is flat or tubular." Bright prospects are indicated for the tricot machine because of its speed in converting yarn into fabric and because of its versatility as exemplified in its ability to produce countless stitch patterns with all types of yarns in a variety of gages. Brief descriptions are given of other types of warp knitting machines; namely, Milanese, plain Raschel, Kayloom, Jacquard Raschel, Marratti machine, Simplex, and Cut-presser machine. R. K. Worner

Loom for Silk and Rayon

A Lancashire loom for silk and rayon fabrics. Anon. *Silk and Rayon* **19**, 650–1 (June 1945).

A description is given of a dobby loom which can weave 40 shafts at the speed of 160 picks per min. and with a reed space of 48 in. The loom has an underpick motion and a new positive take-up motion, which derives its action from a small cam that imparts a rocking motion to the shaft. The harnesses may be operated by the use of lag cylinder or an eight-sided cylinder accommodating jacquard-like cards.

A. L. Merrifield

Processing Nylon

Weaving and finishing of nylon fabrics. P. D. Atwood. *Am. Dyestuff Reptr.* **34**, P184–6 (May 7, 1945).

Three basic properties of nylon yarn which are of great importance in weaving performance and the fabric finishing operation are elasticity, inherent shrinkage, and ability to take a "set." These properties are due

chiefly to the drawing operation during yarn manufacture. Although the drawtwister bobbin contains finished yarn having 8–11% residual shrinkage it is usually given additional twist and sized, during which treatments the yarn relaxes appreciably so that the weaver ordinarily handles a yarn having 5–6 % residual shrinkage. Because of the elastic and shrinkage properties, uniform tensions must be maintained through all processing steps to avoid warp streaks, quilling barre, nonuniform selvedge tension, and similar faults; process control is facilitated if absolute minimum tension is used. Nylon is not considered "set" unless it is submerged for at least 5 min. in boiling water; higher temperatures under saturated moisture conditions give better set in less time; fabric set in boiling water will require steam at 212–225°F in order to undo the set accomplished at 212°F. Thus an unset fabric must not be allowed to wrinkle during the boil-off. Dry heat setting (e.g., 430°F for 10 secs.) is still in the experimental stage but for some purposes promises advantages over steam setting in improved hand, drape, and resilience. C.

Shuttle Guard

New type shuttle guard. Anon. *Textile Recorder* **62**, 52 (June 1945).

A description of a British shuttle guard of simple construction made from either wood or wire is presented. This guard is bolted to the sley, may be raised into the vertical position against the sley when it is necessary to draw the warp ends through the reed, and will drop into the operating position automatically with the first pick. A. L. Merrifield

BLEACHING: DYEING FINISHING

★

Peroxide Bleaching

Continuous peroxide bleaching. The technical staff of the Buffalo Electro-Chemical Co., Inc. *Textile Recorder* **62**, 47–9 (June 1945).

A brief description of the continuous peroxide bleaching of cotton piece goods is illustrated by a flow diagram of the equipment employed. The actual bleaching step is preceded by various treatments, such as water washing, acid treatment, caustic steaming, and acid treatment followed by caustic steaming. These treatments are outlined. Two of the newer developments for centralized control of the continuous system are electronic methods of indicating cloth level in the J-box and conductivity meters for indication of the chemical concentration in each saturator. A. L. Merrifield

Peroxide Bleaching

Peroxide bleach. T. V. Punnoose. *Indian Text. J.* **55**, 555–7 (May 1945).

General. Practical details are given for determining the strength of peroxide, and for using it in commercial bleaching processes, including the continuous process. R. K. Worner

Azo Compounds

The decomposition of azo compounds by distillation with soda-lime. E. J. Cross. *J. Soc. Dyers and Colourists* **61**, 74–6 (Mar. 1945).

Experiments have shown that with certain exceptions distillation of azo dyes with soda-lime results in what is best explained as the hydrolytic fission of the azo group with production of the arylamine (or its sulfonic acid) used as the diazo-component in making the dye. It appears to be essential that there be present in the molecule at least one substituent which forms a salt with the alkali; otherwise the compound is unaffected by the reagent. The experimental procedure employed in isolating the arylamines from the products of the soda-lime distillation of 15 dyes is outlined. C.

Indigosol Dyes

Indigosol dyes. Richard Kunzl. *Tek. Tid.* **70**, *Kemi* 76–7 (1940); *Chem. Zentr.* **1941**, **II**, 1682; cf. *C. A.* **35**, 7198[6] (through *Chem. Abstr.* **39**, 3935[6] (Sept. 10, 1945)).

The constitution, dyeing methods, and suitability of indigosol dyes for various types of textiles are discussed. A table lists the fastness of those dyes best suited for natural and synthetic fibers in accordance with the method of the fastness committee of the Verein Deutscher Chemiker.

Dyeing

Dyers and the study of dyeing. George Brown. *Textile Bulletin* **68**, 36, 38 (June 15, 1945); 32–3 (Aug. 15, 1945).

A two-part article dealing with the historical background of dyeing, essential laboratory equipment, and minimum training to acquire a sound background of technical knowledge required by a dyer. H. J. Burnham

Dyeing Rayon

Dyeing and finishing viscose-acetate rayon linings. II. Dyeing. Anon. *Silk and Rayon* **19**, 431–2, 448 (Apr. 1945).

The second article of a series, which discusses the dyeing of viscose-acetate rayon linings, after scouring, by two methods: (1) direct cotton and acetate rayon dyes in one bath, and (2) dyeing the viscose rayon with a dye stable to diazotization and coupling, when dyeing the acetate rayon with an azo dye. Dyes and couplers suitable for the latter type of dyeing are given. A. L. Merrifield

Sulfur Dyeing

Dyeing of cotton goods in the cold with sulfur dyes. N. A. Vtorova. *Legkaya Prom.* **1944**, No. 6, 18–19 (through *Chem. Abstr.* **39**, 4227 (Sept. 20, 1945)).

It was shown that cotton goods can be dyed by S dyes in the cold, when concentration of over 2 g./l. is used in presence of Na_2S. Further study of pre-treatment of the goods is outlined.

Wool Dyeing Machine

Machines for dyeing wool pieces. XX. Theory and practice of wool dyeing. C. L. Bird. *Textile Recorder* 62, 45–6, 58 (June 1945).

The wince dyeing machine for the dyeing of wool pieces is reviewed and its advantages and limitations listed. The steamy atmosphere of dyehouses employing wince machines has been eliminated by the use of totally enclosed machines, which also results in approximately 50% saving in the amount of steam consumed after the dye liquor has reached operating temperatures.

A. L. Merrifield

Processing Wool Piece Goods

The scouring, dyeing, and finishing of wool piece goods. J. C. Schofield, S. L. Peel, and G. K. Seddon. *J. Soc. Dyers and Colourists* **61**, 90–4 (Apr. 1945).

Three points believed worthy of investigation in connection with wool scouring are (1) possible importance of maintaining the initial pH in removal of oleins from the pieces with soda ash solution alone, (2) actual time required to remove the impurities, and (3) possible suitability of cheaper oils in all departments of wool manufacture. The dyeing methods used for woolen piece goods containing all-wool or shoddy filling and all-wool, shoddy, or all-cotton warp are reviewed. Some processes, including methods of cropping, blowing, damping, and pressing, said to represent improved efficiency in the finishing of fine worsted pieces, are described. C.

Plastic Coatings

Multiproofing fabrics. Benjamin E. Beale. *Plastics* (Chicago), **2**, 36–7, 78–9 (June 1945).

Plastics coatings on cotton, synthetic yarns, combinations of the two, and on paper have been developed to give excellent performance. Coated fabrics are now tailor-made to withstand high hydrostatic pressure, to be fireproof and mildew-resistant, to possess good flexibility at low temperatures, to resist blocking and plasticizer oxidation at high temperatures, to have high abrasion resistance and long flex-life.

E. G. Martin

Calico Printing in India

Calico printing in India and its future. N. K. Patel. *Indian Text. J.* **55**, 243–5 (Jan. 1945).

The Indian machine-printing industry made rapid strides following the depression of 1929–33, and faces bright prospects for the future. Progress is ascribed partly to imports of textile printing machinery, but mainly to the introduction of easily applicable fast dyes specially adapted to printing. Various printed styles used in India are described. R. K. Worner

Glucose in Printing

Glucose in textile printing. A. M. Patel. *Indian Text. J.* **55**, 548–54 (May 1945).

The importance of glucose and related substances as reducing agents in calico printing is emphasized, especially in view of the present high cost and inadequate supplies of the newer synthetic substances, such as hydrosulfites and rongalite. Indigo can be successfully printed by mixing together the dye, caustic soda, and glucose. Procedures are given for printing vat dyes using glucose and allied substances as one of the reducing agents. R. K. Worner

Finishing Rayon

Dyeing and finishing viscose-acetate rayon linings. III. Finishing methods. Anon. *Silk and Rayon* **19**, 546 (May 1945).

The third of a series. This article discusses the mangling, tentering, impregnation to stop fraying, and softening-up of the texture by the stud breaking machine or calender during the finishing of viscose-acetate rayon linings.

A. L. Merrifield

Titanium Compounds for Finishing

Titanium compounds: Their use and disadvantages in the finishing of rayon fabrics. Anon. *Silk and Rayon* **19**, 645, 676 (June 1945).

A general discussion of the uses of titanium compounds for delustering rayon fibers and printed fabrics is given. Four patents are cited: U.S. 2,143,883, whereby the yarn is delustered and dyed by addition of vat dyes with titanium dioxide in a suitable condition to the spinning solution; B.P. 371,239, wherein colloidal aqueous solutions of titanium dioxide are employed in dulling rayon; B.P. 454,968, in which titanium and tin compounds are fixed on textiles employing double salts of weak polybasic acids with volatile bases like ammonia; and B.P. 448,262 points out the fade-resisting value of treating titanium dioxide with water-soluble chromium compounds before adding to the spinning mass. A. L. Merrifield

Lanolin Soaps

Lanolin soaps. Milton A. Lesser. *Soap* **21**, No. 4, 41–4, 86 (1945) (through *Oil and Soap* **22**, 163 (June 1945)).

The chemical properties, structure, and requirements for use of lanolin are discussed. The history of the use of lanolin as a superfatting agent in soaps is reviewed. Superfatting, it was first thought, would eliminate the possibility of free alkali remaining in the finished soap and might combine with the alkali formed by hydrolysis when the soap was dissolved in water. The modern concept is that the use of superfatting materials in soap seems to be directed toward decreasing its defatting effect on the skin rather than toward counteracting its alkalinity. There is a marked resemblance in both composition and function between wool fat and sebum of the human skin. This makes wool fat a logical additive to soap. It also has excellent emollient effects, does not become rancid in soap, does not induce rancidity, does not hinder the homogeneous preparation of soaps, acts as a solvent for perfumes, and does not deepen the tint of soaps. However, it does lower the lathering ability of the soap, but this may be counteracted by use of increased amounts of

coconut oil. From the manufacturers' point of view, lanolin prevents excess free alkali, reduces the tendency to split or crack, and makes the milling process easier. Author

Oil Stains

Lubrication-oil stains in textile goods. G. Ullmann. *Indian Text. J.* **55**, 233–9 (Jan. 1945).

A review of present knowledge. Mechanical and control measures for preventing the formation of lubrication-oil stains, advisable compositions for lubricating oils, and methods for removing stains are discussed. R. K. Worner

Application of Resins

Resins applied to textiles. L. J. Sheps. *Can. Chem. and Proc. Ind.* **29**, 546–8 (Aug. 1945).

A review discussing the general methods by which resins may be applied to textiles, and the properties and uses of the textiles thus treated. 31 references.

E. Dermaner

Resin-Bonded Pigments

Resin-bonded pigment colors. Winn W. Chase. *Modern Plastics* **23**, 100–2 (Sept. 1945).

A review discussing the theoretical aspects and the advantages and disadvantages of the four systems of applying resin-bonded pigment colors to textiles—namely, the pigmented water-in-oil emulsion system, the pigmented oil-in-water system, the solvent dispersion system, and the aqueous dispersion system. E. Dermaner

Shrinkproofing

The use of abrasives to make wool unshrinkable. J. B. Speakman and E. Whewell. *J. Text. Inst.* **36**, T48–56 (Mar. 1945).

The shrinkage of wool fabrics under repeated application of pressure in the presence of aqueous media is due to the migration of the fibers in the direction of their root ends. Such migration is, in turn, determined by the surface scale structure of the fibers, assisted by the ease with which they are deformed and recover from deformation in aqueous media. Conversely, shrinkage can be prevented by masking or removing the scales. Although several methods are available for descaling fibers in the laboratory by means of abrasives, no attempt appears to have been made to descale fibers in bulk and so confer an unshrinkable finish on wool textile materials. It has now been shown that wool fabrics can be made unshrinkable by impregnating them with oil and a finely divided abrasive, followed by mechanical working in a milling machine. Under these conditions the scale edges of the fibers are removed and the effectiveness of the abrasive increases with increasing fineness and hardness. Among a large number of powders examined, 200-mesh (I.M.M.) silica gave the highest degree of unshrinkability. Besides having some practical importance, the new method of making wool unshrinkable has the merit of establishing the fundamental role of the surface scale structure of animal fibers in milling shrinkage. In addition, it provides a means of obtaining descaled fibers in bulk for chemical examination. Author

Shrinkage Control

Wool's new age of discovery: New methods of preventing shrinkage. Charles McCann. *Indian Text. J.* **55**, 564–6 (May 1945).

A review. R. K. Worner

Washing Staple Rayon

The large-scale washing of staple rayon. Karl Pfleiderer and Wilhelm Wertel. *Melliand Textilber.* **25**, 90–2 (1944) (through *Chem. Abstr.* **39**, 4231² (Sept. 20, 1945)).

Large-scale washing tests in ordinary washing machines are reported. Staple rayon is sensitive to strong alkaline washing liquors. Neutral washing agents employed alone are not effective. A mixture of soap with a fatty alcoholic sulfonate or fatty acid condensation product should be used. Bleaching agents at a temperature of 80–85° cause swelling of the fibers. As a cellulose product, staple rayon resembles cotton and linen; as a structure-less fiber which is not protected against wet mechanical stresses, physically it resembles animal textile fibers. Hence, it should be washed chemically, as cotton is, and mechanically, as wool is.

Wool Scouring

Relatively new chemical aids wool scouring. A. H. Razee. *Textile World* **95**, 155, 157, 230, 232, 234 (Sept. 1945).

It is said that the use of sodium tetraphosphate reduces soap consumption substantially and that wool can be scoured with it to any desired grease content without altering its spinning characteristics by fiber damage, while at the same time effecting considerable improvement in the appearance of the wool.

H. J. Burnham

MISCELLANEOUS

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Alginic Acid

Algin—a marine colloid of many uses. Anon. *Chemurgic Digest* **4**, 233, 235–6 (July 31, 1945) (through *Bull. Inst. Paper Chem.* **16**, 4 (Sept. 1945)).

Algin is a dried, purified, mucilaginous substance extracted from kelp—a white-to-cream-colored, amorphous, odorless, tasteless powder. Chemically, it is stated to be the sodium salt of polymerized uronic acid, mannuronic acid in particular. Its solubility in water is limited by the viscosity of the resulting solution; the viscosity curve will rise very rapidly with the increase in the percentage of algin used. The raw material from which algin is derived includes the algae of the genus *Laminaria* found on the northeastern seaboard of the United States, where the kelp is cut by dragging or by hand. It undergoes a curing treatment in a nearby station to pre-

vent fermentation while it awaits further processing. The stabilized kelp is brought to the processing plant in Maine, where the algin is extracted, purified, and dried under vacuum. The present uses of the material are manifold; its remarkable characteristics as a colloidal stabilizer, emulsion stabilizer, dispersing agent, and thickening agent have resulted in its adoption in widely diversified fields, such as the drug, pharmaceutical, cosmetic, textile finishing, textile printing, rubber, cold water paints, agricultural, food, ice cream, confection, and paper industries.

Alginic Acid Rayon

Rayon from alginic acid being developed in England. Anon. *Chem. and Eng. News* **23**, 1717–18 (Oct. 10, 1945).

A summary of progress to date (1945) in the development of the production of rayon from seaweed. The physical properties of alginate and calcium rayons are outlined. J.

Casein Production

Casein uses stimulate output. Susan M. Phillips. *Chemurgic Digest* **4**, 204–6 (June 30, 1945) (through *Bull. Inst. Paper Chem.* **15**, 446 (Aug. 1945)).

Statistical information on the manufacture of casein in the United States is given, which is at present largely produced in Wisconsin, California, and New York, from where about 60% of the 1943 output came. The heavy demand for powdered whole milk during the war resulted in an approximate reduction of 66% from 1941 to 1944. Domestic consumption reached an all-time peak of almost 90,000,000 lbs. in 1941, when domestic production amounted to more than 47,000,000 lbs. and imports—chiefly from Argentina—totaled 42,000,000 lbs. One of the biggest users of casein is the paper coating industry; other uses are for adhesives and paints, fibers, as binding agent in wallboard, as stabilizer in rubber latex compounds, as finishing agent for leathers, for plastics, etc. When the current requirements for powdered milk are lessened, casein consumption may become even greater than in 1941.

Cellulose Derivatives

Cellulose plastics. L. T. Barnette. *Chemurgic Digest* **4**, 185, 187–8 (June 15, 1945) (through *Bull. Inst. Paper Chem.* **15**, 447 (Aug. 1945)).

The author discusses in a popular manner a number of cellulose derivatives, their properties, and possible applications, including their use as coating materials.

Coal Consumption

Climate and cotton mill coal consumption. Anon. *Am. Wool and Cotton Reptr.* **59**, 13–14, 29 (Aug. 30, 1945).

Comprehensive data on coal and steam consumption in a mill in Massachusetts and one in South Carolina. Some other figures from several representative mills are given. A finishing consultant is quoted as saying that the additional coal required for heating during the winter in the north is offset by a greater consumption of coal in the south for additional humidification. H. J. Burnham

Colloids from Kelp

Colloids from kelp give rise to a unique process industry. C. K. Tseng. *Chem. and Met. Eng.* **52**, 97–100 (June 1945) (through *Bull. Inst. Paper Chem.* **16**, 5 (Sept. 1945)).

Processing of colloids from seaweeds has grown into a sizable chemical industry, algin being tonnage-wise the most important product. It is produced from kelp by two basic processes, the Green cold process, and the LeGloahec-Herter process which may be carried out hot or cold. A brief description is given of the algae used, the products derived, methods of harvesting kelp, the two processes for extracting algin, its present uses, and possible applications. A list of producers of seaweed colloids in the United States is included.

California Cotton

Plans for California cotton mill suggest trend to West. Anon. *Textile World* **95**, 92–3 (Aug. 1945).

Specifications for a 15,000-spindle cotton mill proposed by Lockwood Greene, textile engineers, to be located in California, using local irrigated cotton to make denims, gabardines, twills, seersuckers, and poplins for local consumption. Tests have revealed that the cotton to be used should have light beating and picking and low card production to keep down neps and that the resultant yarn will rate A− to B+. Mill operation will probably start in about 3 years. Complete recommended machinery list is given, from the opening room to the dye house and finishing room. H. J. Burnham

Chemical Composition of Cotton

Survey of the chemical composition of cotton fibers, cottonseed, peanuts, and sweet potatoes. A literature review. John D. Guthrie, Carroll L. Hoffpauir, Edward T. Steiner, and Mack F. Stansbury. U. S. Dept. Agr., Southern Regional Research Lab. AIC-61, 86 pp. (1944) (through *Chem. Abstr.* **39**, 3812[7] (Sept. 10, 1945)).

A review of data on the chemical composition of cotton fibers, cottonseed, peanuts, and sweet potatoes, together with 67, 91, 92, and 73 references, respectively, to the chemical composition of these commodities.

Cotton Linters

History of the cellulose yield procedure. L. N. Rogers. *Oil and Soap* **22**, 24 (June 1945).

A brief history is given of the Cellulose Yield Committee of the American Oil Chemists Society. It is credited with having taken the buying and selling of cotton linters out of the "horse trading" category and put it on a sound scientific basis. A. R. Martin

Elastic Cotton Gauze

Chemical treatment produces elastic cotton gauze. Anon. *Textile World* **95**, 131 (Aug. 1945).

A description of a pre-shrunk, mercerized cotton gauze which is said to make a self-fitting and self-tightening bandage. H. J. Burnham

Lignin

Lignin—an economic liability or a chemical asset. Harry F. Lewis. *Chem. Eng. News* **23**, 1074–80 (June 25, 1945) (through *Bull. Inst. Paper Chem.* **15**, 458 (Aug. 1945)).

Reference is made to the bast lignin wastes from farms and forests in the United States. So far, the efforts of many technologists and chemists from different countries have not disclosed methods for a large-scale utilization. Stories in the popular press notwithstanding, the problem of lignin is essentially the same in 1945 as at the time of Payen's discovery of the material in 1838. The author reviews the sources of lignin, including the collection and disposal of lignin wastes, types, physical and chemical properties, and methods of utilization in various forms to date. A knowledge of the structure of lignin is a prerequisite for further developments and the solution of the lignin problem. Some fundamental studies have been made and have resulted in relatively small-scale developments when measured against the over-all picture. A concentrated attack on the problem by organic chemists, high-polymer chemists, physical chemists, and physicists will help toward the solution of the positive characterization of the material. Before a new chemical industry can be developed on the basis of lignin, it must be demonstrated that the proposed operations are economically sound when measured against similar products derived from other available raw materials. Whether lignin is an economic liability or a chemical asset has not yet been determined. To obtain the answer may be expensive in time and money, but in the interest of conserving the dwindling stores of natural resources, particularly those slowly accumulated over geologic ages, it is essential that the solution be found.

Polyethylene Insulators

Polyethylene in coaxials. C. Kreisher. *Plastics* (Chicago) **3**, 34, 36, 157, 159 (July 1945).

Polyethylene is successfully used for insulation disks in coaxial cables for television. Because of its low power factor, the shunt losses were reduced to $\frac{1}{12}$ of the number for disks made of rubber. Physical properties are listed. E. G. Martin

Rope Drives

Rope drives. Anon. *Textile Recorder* **62**, 57, 61 (June 1945).

Equations are given for friction force, tensions, horsepower transmitted, and centrifugal force of cotton, hemp, and Manila rope drives. A series of curves show the horsepower which can be transmitted with various ropes at different speeds and indicates how the centrifugal force reduces the power at high speeds; it is not advisable to run at speeds exceeding about 4,800 ft. per min. The diameter of pulleys used with cotton ropes should be preferably not less than 30 times that of the rope, while pulleys at least 40 times the rope diameter are suggested for hemp and Manila rope drives. Also, a simple trip device is illustrated which may be employed to stop an electric motor when a rope breaks during operation.
A. L. Merrifield

Transformers

Installation and care of transformers. Anon. *Silk and Rayon* **19**, 549, 553 (May 1945).

General information on the installation and care of power transformers, including housing, isolated secondary switch, and oil-immersed safety switches, is presented, with diagrams showing an overload and earth leakage protective circuit for a three-phase delta-star transformer. Methods for removing moisture from the transformer oil and keeping moisture out of the oil while it is in the transformer are described.
A. L. Merrifield

Water Purification

Threshold treatment of water. J. C. Skerrett. *Can. Chem. and Process Ind.* **29**, 226–9 (Apr. 1945).

A discussion of the chemical treatment of water to preserve boiler surfaces from scale, and of obtaining a temporary equilibrium in water through the addition of phosphates to prevent scale and corrosion in the supply systems. This threshold treatment utilizes the absorption property of meta-phosphates.
E. G. Martin

Fire Prevention

The prevention of fires in woolen mills processing wool in admixture with cotton or other cellulosic fibers. R. D. Preston and C. S. Whewell. *J. Text. Inst.* **36**, P36 (Mar. 1945).

A note giving six recommendations to reduce fire hazards. A. R. Martin

Cloth Room Layout

Reducing cloth room costs at Pacolet Mfg. Co. Anon. *Cotton* **109**, 104–6 (Aug. 1945).

A description of the new cloth room layout at the Pacolet mill in Pacolet, S. C., with a diagram of the arrangement of equipment and pictures. Full advantage is taken of conveyors and automatic and semi-automatic devices for handling cloth. It is said that costs have been reduced substantially. H. J. Burnham

Wool Layout

Relocating for continuous processing in woolen yarn mills. Gustav Zellnik. *Textile World* **95**, 119, 184, 186 (Aug. 1945).

A discussion of modernization emphazing the relocation of machinery in opening and scouring rooms, using pneumatic pipe lines and aprons to eliminate much manual handling of material. H. J. Burnham

Japan's Woolen Industry

Japan's woolen industry. Anon. *Textile Recorder* **62**, 63, 65 (June 1945).

A condensed review of the growth of the woolen industry in Japan is presented with figures on the spindles, looms, and amount of woolen cloth produced up to 1938. Tables show the number of workers, production, exports of woolen fabrics, and imports of wool into Japan.

A. L. Merrifield

New Zealand Textile Market

Export market review: Prosperity in New Zealand. Anon. *Silk and Rayon* **19**, 561–2 (May 1945).

A condensed review of imports by New Zealand of textile materials is illustrated by tables for the years 1937–39. Facts and figures are also presented on New Zealand's economic stability and its increasing imports of rayon and other man-made fibers. A. L. Merrifield

Wages in Textile Industries

Earnings in the textile industry. Part II. Anon. *Textile Recorder* **62**, 36–38, 49 (June 1945).

In this article information has been collected on the wage earners in the eleven major British textile industries. The hourly and weekly earnings of wage earners and the number of hours worked since October, 1938, are summarized in tables and graphs; also the earnings in the major textile industries are compared with average earnings in all industries. The manual wage earners are subdivided under the following headings: men 21 years and over; youths and boys under 21 years; women 18 years and over; girls under 18 years.

A. L. Merrifield

PATENT REFERENCES

★

Cotton Cleaner

Novel cleaning mechanism. Lucien L. McDaniel and Frank E. Deems (to Continental Gin Co.). U. S. 2,384,383 (Sept. 4, 1945).

In this invention the usual screen surface is replaced by a series of rotating cylinders having agitating and cleaning elements spaced to provide the maximum opening for dirt and trash but close enough to provide a screen for the cotton.

Wool Combing

Wool combing machine. Hachig Sarkisian. U. S. 2,384,344 (Sept. 4, 1945).

Special mounting of plows by which the wool fiber is lifted out of the pins in a comber.

Drive Control

Drive control for warping and winding apparatus. John C. Bodansky and Ernest K. Whitener (to Cocker Machine & Foundry Co.). U. S. 2,384,879 (Sept.18, 1945).

The primary object of the invention is to make it possible to automatically maintain a constant speed in the yarn notwithstanding the gradual increase in the diameter of the beam during the winding operation.

Decorticating Machine

Decorticating of flax and other bast fibers. John Thomson. U. S. 2,385,427 (Sept. 25, 1945).

Knitting Machines

Improved tension control, stop mechanism, and warning signal for knitting machines. Robert N. Auble. U. S. 2,383,838 (Aug. 28, 1945).

Light Polarizing Device

Light polarizing screen and method of manufacture. Chalon W. Carnahan (to Sylvania Electric Products, Inc.). U. S. 2,385,687 (Sept. 25, 1945).

A novel screen in which certain sections will polarize the light in one plane and other sections will polarize the light in the transverse direction.

Looms

Buffer for loom bobbin receivers. Richard G. Turner (to Crompton & Knowles Loom Works). U. S. 2,380,807 (July 31, 1945).

Improved bobbin buffer for bobbin cans or receivers.

Improved weft replenishing, pick-and-pick, filling mixing loom. Albert Palmer and Elliot A. Santon (to Crompton & Knowles Loom Works). U. S. 2,380,544 (July 31, 1945).

Bleaching and Scouring

Treatment of cellulosic textile materials. George P. Vincent, Archie Louis Dubeau, and John Francis Synan (to The Mathieson Alkali Works, Inc.). U. S. 2,383,900 (Aug. 28, 1945).

A process for bleaching and scouring, using package machines, is described by which it is stated that the results are: good color, decrease of oxycellulose, and the process may be carried out with a smaller amount of available chlorine than when a hypochlorite is the only bleaching agent. A mixture of sodium chlorite and a hypochlorite to which a suitable detergent has been added is employed at a pH between 8 and 11. A moderate temperature of approximately 120°F is maintained until bleaching is complete. The temperature is then raised to approximately 200°F, which permits scouring to take place owing to the action of the detergent.

Application of Coatings

Fabric coating machine. Francis B. Quinn and Robert G. Levitch (to Bigelow-Sanford Carpet Co., Inc.). U. S. 2,384,695 (Sept. 11, 1945).

A fabric coating machine having in combination a chamber open at top and bottom and having vertical sides, two sets of burnishing rolls to rotate at a surface speed of 15 to 30 ft. per second, a tank located below the chamber and adapted to contain a rubber solution, a roll dipping into this tank, means to guide

the incoming dry fabric against the sides of the rolls of one set with which sides the wet fabric does not make contact, and means to guide the wet fabric against the opposite sides of said rolls and against the other set of rolls in the chamber.

Dyeing Cellulose Acetate

Coloring cellulose acetate and other cellulose esters or ethers by application of solutions of water-insoluble arylamino anthraquinones. Alexander James Wesson (to British Celanese, Ltd.). U. S. 2,384,001 (Sept. 4, 1945).

By the process described in the patent it is stated that a good range of shades may be obtained which have excellent fastness to light, washing, cross-dyeing, and gas.

Dyeing Rayon

Dyeing. Cyril M. Croft and Walter H. Hindle (to Celanese Corp. of America). U. S. 2,380,503 (July 31, 1945).

Organic derivatives of cellulose textile materials may be dyed rapidly in level shades by dissolving the dyes in an organic liquid medium consisting of an aqueous solution of a lower aliphatic ketone, such as acetone or methyl ethyl ketone, but preferably acetone, and applying the resulting dye solution to the textile material by mechanical impregnation.

Fabric Treatment

Resin treatment for fabrics which are to be napped or brushed. Cyril Pearson Atkinson (to Courtaulds, Ltd.). U. S. 2,384,871 (Sept. 18, 1945).

A napped fabric woven from mixtures of cotton, wool, regenerated cellulose, and casein if treated by the process described in the patent is stated to possess an improved handle and appearance.

Sizing Process

Treatment of textile materials. George W. Seymour and Dustin Y. Miller (to Celanese Corp. of America). U. S. 2,385,110 (Sept. 18, 1945).

The patent covers the treatment of saponified, stretched cellulose acetate yarns in such a way that they are rendered more amenable to textile operations. The process consists of the application to the yarn of a sizing composition comprising a polymerized ethylene oxide, a wetting or penetrating agent, and a polymethacrylic acid or derivative thereof.

Yarn Conditioning

Treatment of textile materials. George W. Seymour and Walter Brooks (to Celanese Corp. of America). U. S. 2,385,423 (Sept. 25, 1945).

A conditioning compound applicable to cellulose yarns consists of a white mineral oil, a modified vegetable oil, an alkylated phenol or other wetting agent, a fatty acid, and an alkylolamine. It is stated that the treatment described improves the behavior of the yarns in winding, twisting, weaving, and knitting. Yarns so treated are not adversely affected by storage. Nine examples of suitable conditioning liquids are given.

Elastic Fabric

Improved elastic fabric and method for producing the same. Samuel C. Lilley and Edward E. Foster (to United Elastic Corp.). U. S. 2,384,936 (Sept. 18, 1945).

The invention relates to improvements in woven elastic fabrics in which the elastic strands are so anchored as to minimize creepage.

Knitted Fabric

Knitted fabric with elastic selvage. Robert H. Lawson (to Scott & Williams). U. S. 2,380,768 (July 31, 1945).

Knitted fabric with elastic selvage. The principal object of the invention is to provide a non-curling selvage for self-supporting stocking tops.

Elastic Thread

Method of handling elastic thread and product thereof. Sterling W. Alderfer (one-half to Edward D. Andrews). U. S. 2,380,373 (July 31, 1945).

Method for manufacturing elastic thread and incorporating it in fabrics. A sheet is formed by applying an adhesive to one or more layers of parallel elastic filaments. The surface only of the sheet is then dried, and afterward separated into the individual filaments while the interior is still in a tacky condition. A covering is then applied to the individual filaments.

High Strength Yarns

Composite, bonded yarns. William Whitehead (to Celanese Corp. of America). U. S. 2,380,003 (July 10, 1945).

The patent relates to the production of compact, composite, bonded yarns. According to this patent, strong yarns of stretched, saponified cellulose acetate or other organic esters of cellulose are twisted or otherwise associated with thermoplastic yarns having a basis of cellulose acetate to form a composite yarn. This composite yarn is then subjected to the action of vapors of a softening agent for the thermoplastic material. Preferably, the associated yarns are subjected to a vacuum prior to being exposed to the vapors of the softening agent. As a result of this process, it is possible to obtain flexible, permanently compact, composite, bonded yarns of unusual strength.

Marking of Fabrics

Method of identification marking of fabrics. John Miglarese (to National Marking Machine Co.). U. S. 2,384,039 (Sept. 4, 1945).

A method of applying permanent identification marks to fabrics, which consists in placing a thin sheet of rubber upon a fabric to be marked, heating a type to the degree necessary to melt the rubber immediately adjacent to the type face, pressing the type against the rubber sheet until the melting occurs, removing the type, and finally removing the unmelted portion of the sheet.

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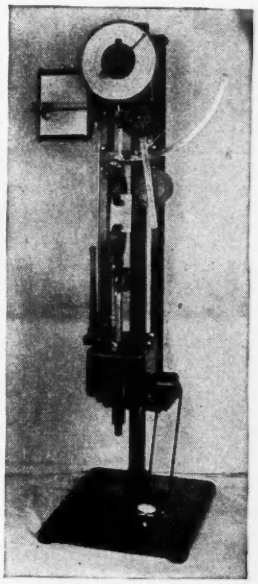

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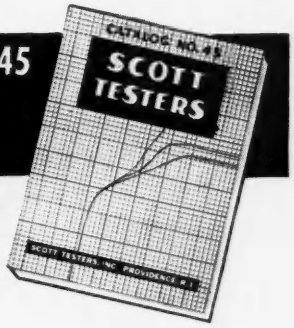

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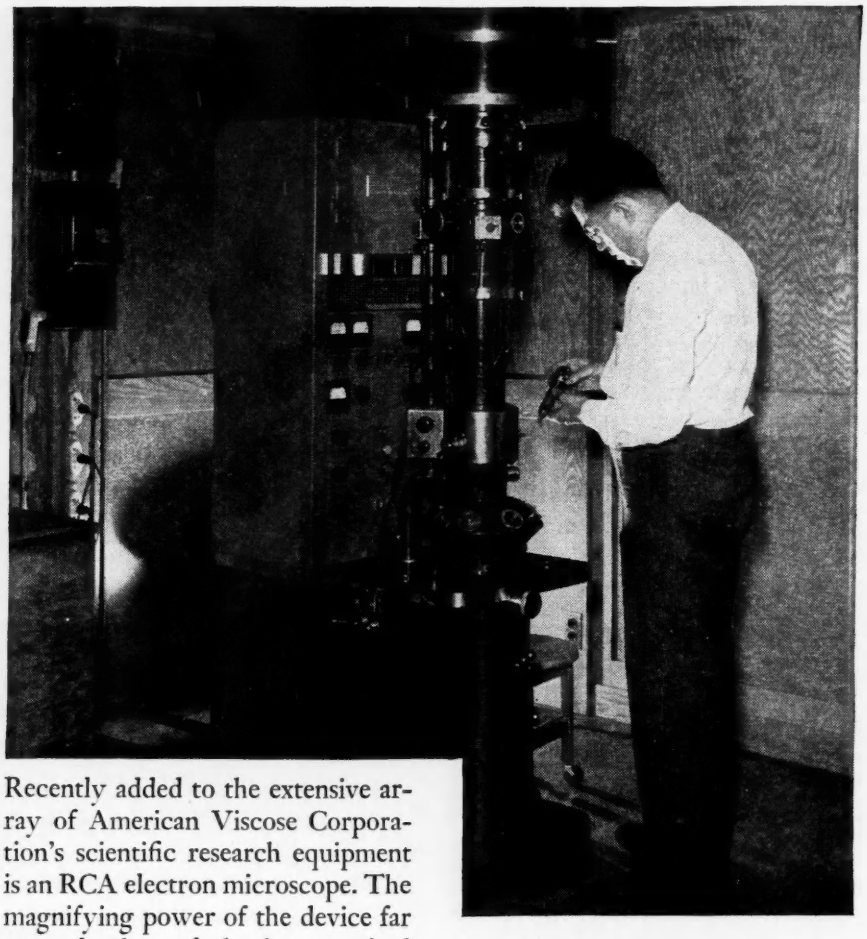
RAYON REPORTS

Published Monthly by American Viscose Corporation, New York, N. Y. DECEMBER, 194

ELECTRON MICROSCOPE USED IN NEW RAYON RESEARCH STUDIES



Recently added to the extensive array of American Viscose Corporation's scientific research equipment is an RCA electron microscope. The magnifying power of the device far exceeds that of the best optical microscope, with magnifications up to 50,000 diameters easily obtainable.

Installed in the Corporation's Chemical Research Laboratory, Marcus Hook, Pa., the microscope is an electronic device that permits scientists to see objects far smaller than anything heretofore made visible to the human eye. It is used both in long range academic research and in immediate projects dealing with the structure and chemistry of rayons, with the objective of improving rayon and extending its applications.

New Fabrics Approved as CROWN Tested

Among the new rayon fabrics recently approved under the CROWN* Tested Plan are the following:

Cohn-Hall-Marx's "Pancoast," an all spun viscose rayon fabric, finished by Waldrich Co., Allied Textile Printers, and Housatonic Dyeing and Printing Co., Inc., approved for hand washability, for dresses and blouses.

Verney Fabric's trio of fuji, broadcloth and thick-and-thin types of all spun vis cose rayon fabric, finished by Kenyon Fin ishing Co.; approved for washability, fo men's dress and sport shirts.

Ripley's "Hostess Crepe," 100% visco and-acetate rayon fabric, woven and dy by Stonecutter Mills; approved for han laundering, for blouses and lingerie.

Rose Fabric's "South Wind," 100% vis cose-and-acetate spun rayon fabric, fi ished by Allied Textile Printers, Ray Dyers and Printers, Inc., and Housato Print Works; approved for hand washab ity, for sportswear and dresses.

Stehli's "Trikspun," an all spun visco rayon fabric, finished by Acme Finishi Co., Lawrence Print Works, and Unio Piece Dye Works; approved for ha washability, for dresses.

Briggs F. Spach's "Laurelle," all spun ray fabric, finished by Sussex Dye & Pri Works; approved for hand washability, f dresses and sportswear.

Traub-Lyons-Oppenheim's new all sp rayon fabric, finished by Sales Finish Co.; approved for washability, for pa mas.

Crest Fabrics' "Fandango," all spun ray fabric, finished by Shamokin Dye & Pri Works, Inc.; approved for hand washab ity, for women's and children's wear.

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2 FABRIC DEVELOPMENT
Helps you design new fabrics.

3 TEXTILE RESEARCH
Helps solve production and finish ing problems.

4 "CROWN*" TESTED
Helps provide scientific selling facts.

AMERICAN VISCOSE CORPORATION
America's largest producer of rayon yarns and staple fibers

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*Reg. U. S. Pat. Off.

TEXTILE TESTING

AN INTEGRAL PART OF RESEARCH IN INDUSTRY'S PROGRAM OF TECHNOLOGICAL ADVANCEMENT

The role of science in the textile industry is becoming more and more important. The great technological advancements which are now being announced in textiles had their origin in the test-tubes and retorts of the textile research engineer. And Testing has taken its place side by side with Research in perfecting such important developments as:

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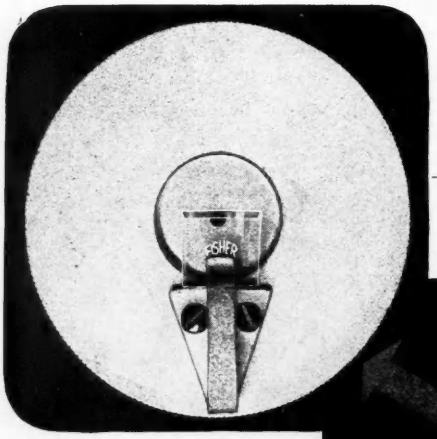
THE MODERN INSTRUMENT FOR MEASURING REFRACTIVE INDEX



The sample placed in the wedge-shape "well" at the eyepiece refracts the light seen through the 2-mm. aperture.

Making a reading with the Fisher Refractometer requires less than a minute: the sample required for the liquid prism is but a very small drop.

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